NASA SP-7037 (276)
March 1992

P-194

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

STI PROGRAM
SCIENTIFIC & TECHNICAL INFORMATION

NASA SP-7037 (276)
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AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

National Aeronautics and Space Administration
Scientific and Technical Information Program
Washington, DC 1992

INTRODUCTION

This issue of *Aeronautical Engineering—A Continuing Bibliography* (NASA SP-7037) lists 705 reports, journal articles, and other documents originally announced in January 1992 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA).*

Accession numbers cited in this issue are:

STAR (N-10000 Series)	N92-11966 — N92-13925
IAA (A-10000 Series)	A92-13249 — A92-17254

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the publication consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals.

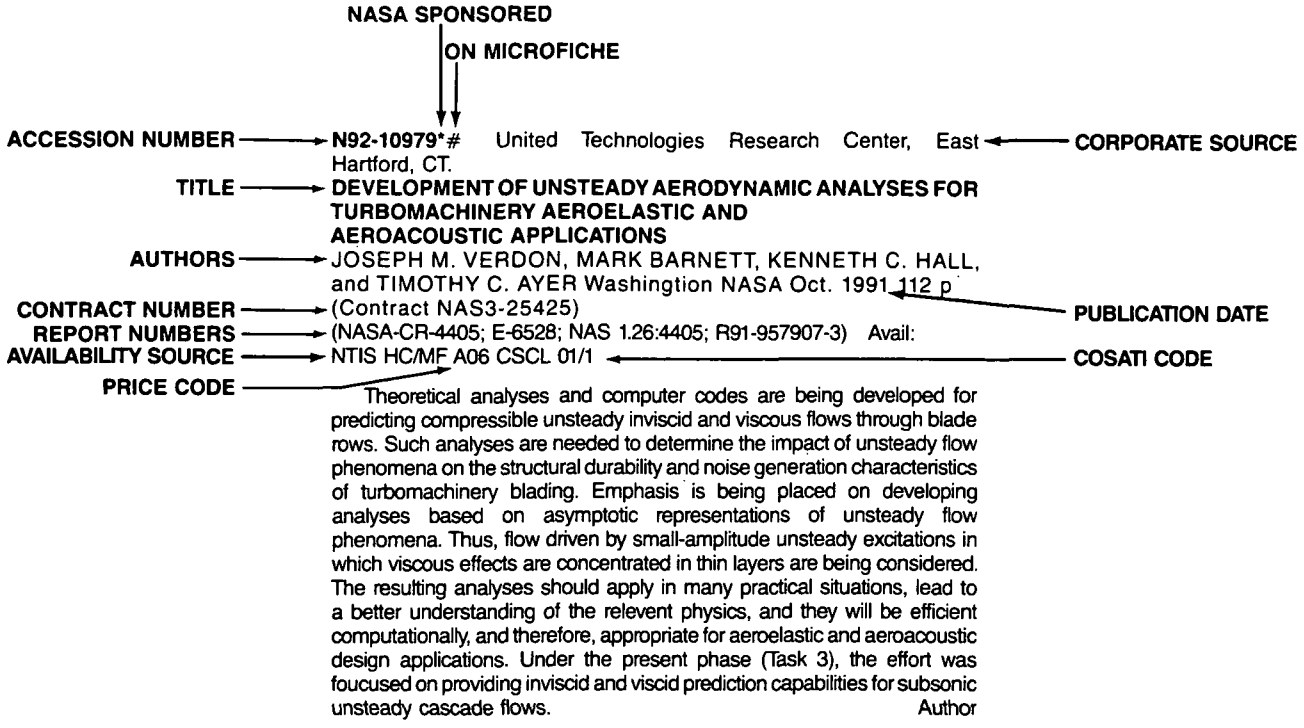
Seven indexes—subject, personal author, corporate source, foreign technology, contract number, report number, and accession number—are included.

A cumulative index for 1992 will be published in early 1993.

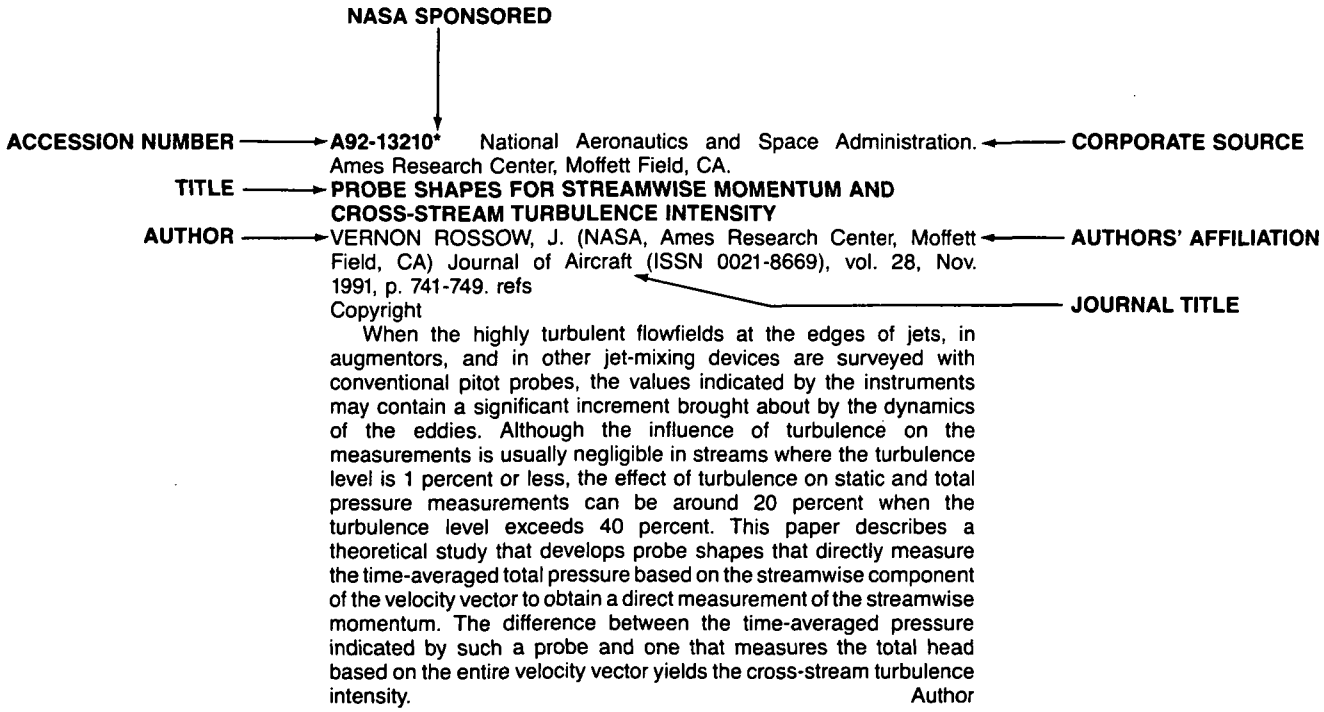
Information on availability of documents listed, addresses of organizations, and NTIS price schedules are located at the back of this issue.

CONTENTS

TYPICAL REPORT CITATION AND ABSTRACT



TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT



AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 276)

MARCH 1992

01

AERONAUTICS (GENERAL)

A92-14326
AHS, ANNUAL FORUM, 47TH, PHOENIX, AZ, MAY 6-8, 1991, PROCEEDINGS. VOLS. 1 & 2
Alexandria, VA, American Helicopter Society, 1991, p. Vol. 1, 775 p.; vol. 2, 772 p. For individual items see A92-14327 to A92-14440.
Copyright

The present conference on helicopter technologies discusses a 3D analysis of a rotor in forward flight, V-22 flight-test aerodynamics, the identification of higher-order helicopter dynamics using linear modeling methods, the evaluation of novel statistical methods for safe-life reliability, a full-scale airframe high cycle fatigue test methodology, and practical robustness testing for helicopter flight control systems. Also discussed are the mechanics of a curved-fiber composite, expanding Marine Corps roles for the AH-1W helicopter, rotorcraft maneuverability/agility-survivability sensitivity analysis, the prototype development of the helicopter air-to-air value-driven engagement model, V-22 effectiveness in land combat operations-support, the design manufacture of an advanced thermoplastic horizontal stabilator, a full-mission simulation data system, stress analysis of composite rotor systems, and an NDT assessment of the V-22. O.C.

A92-14341
CONTINUATION OF THE AHS ROUND ROBIN ON FATIGUE RELIABILITY AND DAMAGE TOLERANCE
G. SCHNEIDER (Sikorsky Aircraft, Stratford, CT) and C. GUNSALLUS (Kaman Aerospace Corp., Bloomfield, CT) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 225-234. refs
Copyright

The American Helicopter Society's Fatigue and Damage Tolerance Subcommittee has completed an investigation of issues pertinent to reliability which have arisen in connection with the introduction of composites, flight data recorders, onboard computers, etc. Attention is presently given to results of evaluations regarding safe life vs damage-tolerant design practices, deterministic vs statistical (reliability) analysis, and individual vs fleet component retirement policies. A projected second round of investigations by the Subcommitte will encompass the issues of reliability sensitivity, the economics of individual-aircraft tracking, usage variability, strength distributions, and the introduction of fracture mechanics analyses. O.C.

A92-14347
EXPANDING U.S.M.C. ROLES FOR THE AH-1W SUPERCOBRA
CURTIS T. CREWS (U.S. Navy, Naval Air Systems Command, Washington, DC) and KAYDON A. STANZIONE (Praxis Technologies Corp., Woodbury, NJ) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 307-318. refs
(Contract N00019-90-C-0195)

A study has been conducted to identify the merits of applying advanced-technology developments to the Marine Corps' AH-1W helicopters, in order to enhance its ability to meet escalating mission requirements. A four-bladed rotor demonstration program has been conducted and judged to indicate the low risk involved in developing an improved AH-1W which will be capable of air-air combat. The use of the four-blade main rotor will lower life-cycle costs, decrease vulnerability, lower vibration levels, and increase productivity. O.C.

A92-14349
VALUE OF SURVIVABILITY ENHANCEMENT TECHNIQUES
MICHAEL D. HOMILLER (LTV Aircraft Products Group, Dallas, TX) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 337-342. refs
Copyright

Military helicopter survivability is dependent on a multitude of interrelated conditions including the nature of the threat; susceptibility factors such as evasive tactics, countermeasures, and intelligence on enemy deployments; and vulnerability reductions measures. An understanding of the relative value of these measures is vital to the designer, who must optimize a mix of techniques - sometimes complementary and sometimes competitive - at a constrained cost. A recent study at LTV has confirmed the overriding value of terrain flight to survivability enhancement and identified signature reduction as an important, though secondary, contributor. Vulnerability reduction has great value when small numbers of threat projectiles are encountered, but the utility of vulnerable area reduction diminishes with an increased number of hits. The lethality of current threat weapons can deny large areas of the battlefield to helicopters. Modern survivability techniques serve to reduce the size of these denied areas. Author

A92-14354
THE DESIGN AND MANUFACTURE OF AN ADVANCED THERMOPLASTIC HORIZONTAL STABILATOR FOR THE AH-64A
MARCIA L. VITLIP, ALAN D. STEMPLE, and THOMAS R. LEE (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 381-389.
Copyright

The AH-64A helicopter's horizontal stabilator has been replaced with a graphite fiber-reinforced thermoplastic matrix structure in order to demonstrate such composites' unique fabrication and assembly methods. The design attempted to achieve a 20 percent weight reduction relative to a metallic baseline, as well as a 50-percent major parts-count reduction. The target weight reduction was achieved, in conjunction with a 40-percent reduction in parts count. Static test results on the composite stabilator have demonstrated the adequacy of the design concepts, manufacturing methods, and FEM modeling techniques employed. O.C.

A92-14411
COMMITTEES, THEIR IMPORTANCE TO THE STRUCTURES OF THE HELICOPTER ASSOCIATION INTERNATIONAL

ROBERT D. FOX (Hillcrest Aviation Co., Lewiston, ID) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 1167-1170.
Copyright

The maintenance of an active and balanced committee structure is a constant concern of the board of directors and the staff members at HAI headquarters. The working committees assist in the development of the helicopter industry. Terms-of-reference are the criteria used for establishing the makeup, agenda, and direction of each committee. An account is presently given of committee members' duties, current projects, and accomplishments to date. O.C.

A92-14413
A HOLISTIC APPROACH TO SUPPORT
ROBERT M. DEVIN (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 1175-1179.
Copyright

The paper presents holistic approach to support that views product support, customer support, and infrastructure support as separate requirements. A successful holistic approach to support is described as occurring when: (1) it is the object of the support effort that drives strategy rather than adherence to established support concepts; (2) the object's true support needs are anticipated and made paramount in the design philosophy; (3) these concepts are incorporated in the design through a true concurrent engineering process that has matured into concurrent product definition; (4) it is structured by combining the best mix of methodologies selected from both military and commercial logistics support; and (5) applied with the concept of the customer as a partner in the industry of applying helicopter technology. Author

A92-14414
MAINTENANCE, MALFUNCTION INFORMATION REPORT SYSTEM
FRANK L. JENSEN, JR. (Helicopter Association International, Alexandria, VA) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 1181-1183.
Copyright

The Maintenance, Malfunction Information Report (MMIR) system and analogous systems, including warranty claims, are examined, with emphasis on maintenance malfunction reporting in the U.S. How the MMIR system will be eventually of considerable benefit to the aviation industry is discussed. Attention is given to the various uses of MMIR, namely, reliability and maintainability filing, supply of spare parts, direct operating cost reduction, and TBO adjustment. P.D.

A92-14435
SPARES SUPPORT OF YOUR ROTARY-WING JENNY
ROBERT R. WALKER (Boeing Defense and Space Group, Helicopters Div., Philadelphia, PA) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 1477-1481.
Copyright

The paper addresses the procurement of spare parts for operational helicopters that are no longer in production and focuses on the technical and financial ramifications of wear, depreciation, and replacement. Combined procurement involves the attempt to address several customer requests simultaneously. The strategy is employed in conjunction with the following concepts: phased procurement and manufacturing, the joint utilization of high-value assets, and inventory financial-risk sharing. Specific strategies outlined include the use of a management reserve memo to coordinate multiple-customer acquisitions and thereby control the finacial risk of inventory maintenance. The out-of-production helicopters including the Rotary-Wing Jenny can be supplied with spare parts and repair material in reduced amounts of time and at reasonable cost. C.C.S.

A92-14437
HOW TO SUPPORT THE 'LITTLE GUY'
RONALD R. LONG (Textron Lycoming, Stratford, CT) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 1501-1505.
Copyright

This paper is designed to spark questions and debate in order to make both OEMs and operators look at how they execute and promote maintenance practices in the helicopter industry, specifically the small operator. The quality of the maintenance performed in the field is directly related to how the A & P mechanic of a small operator is supported by the small operator and OEMs. Planning and supporting the elements of maintenance and how they relate to OEMs and small operators is discussed. Author

A92-14438
MALFUNCTION/DISCREPANCY REPORTING
JOE B. SWIFT (Aerospatiale Helicopter Corp., Grand Prairie, TX) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 1507-1510.
Copyright

Reduced direct operating costs (DOCs) of aerospace products are discussed in terms of the timely and consistent reporting of malfunctions and discrepancies. Early component removals are discussed in terms of the impact of being reported on areas such as engineering and repair. Overhaul facilities provide significant data regarding malfunctions and discrepancies, and the information can aid in the identification of broad problems that lead to increased DOCs. When early component removals are not reported to the manufacturer the effect and magnitude of the problem is underestimated on a fleet-wide basis. Teardown analyses are found to be crucial for identifying individual components that fail within larger systems. It is argued that low DOCs are directly dependent upon the accurate and timely reporting of malfunctions and discrepancies. C.C.S.

A92-14442
EFFECTIVENESS OF V-22 TILTROTORS IN SUPPORT OF LAND COMBAT OPERATIONS
ARNOLD S. WARSHAWSKY (Lawrence Livermore National Laboratory, Livermore, CA) AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Paper. 18 p. Research sponsored by Bell-Boeing Joint Program Office. refs
(Contract W-7405-ENG-48)

The Janus combat simulation was used to compare the relative effectiveness of three aircraft fleets to reinforce a ground combat operation. The simulation permittted assessing the relative capabilities of these fleets in terms of the outcome of the reinforced combat operation instead of simply tabulating the tonnage delivered. The tactical scenario was selected to stress time-sensitive mobility requirements and to require the aircraft to negotiate a low- to mid-intensity air defense threat. It concludes that, for the scenario examined, a fleet composed of V-22 tiltrotors and CH-53E helicopters is more effective than an alternative fleet composed of CH-60(S) and CH53E helicopters. Author

A92-14447
P120 PROGRAMME - FIRST RESULTS OF THE PRE-DEVELOPMENT PHASE
M. RUSSIER (Aerospatiale, Division Helicoptere, Marignane, France) AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Paper. 9 p. refs

The history of helicopter development at Aerospatiale is briefly reviewed, and the current P120 development program is discussed in some detail. The discussion covers the technological approach, the program schedule, architecture and operational aspects, and general technical and performance characteristics of the P120. The technical description of the P120 helicopter covers the main rotor, the fenestron tail rotor, and the structure. V.L.

A92-15022
FROM THE HISTORY OF SOVIET AVIATION - AIRCRAFT OF THE IL'IUSHIN DESIGN BUREAU (2ND REVISED AND ENLARGED EDITION) [IZ ISTORII SOVETSKOI AVIATSII - SAMOLETY OKB IMENI S.V. IL'IUSHINA /2ND REVISED AND ENLARGED EDITION/]
GENRIKH V. NOVOZHILOV, DMITRII V. LESHCHINER, VIKTOR M. SHEININ, M. S. BOL'SHAKOV, S. I. DMITRIEV, IU. A. EGOROV, N. S. TEREKHOV, and IU. I. IUDIN Moscow, Izdatel'stvo Mashinostroenie, 1990, 384 p. In Russian. refs
Copyright
The three main aspects of the work of the Il'iushin design bureau are reviewed: attack aircraft, long-range bombers, and civilian aircraft. Particular attention is given to the transportation and weight efficiency of the Il aircraft, and to some aspects of weight design. L.M.

A92-16059* NASP Joint Program Office, Wright-Patterson AFB, OH.
THE NASP PROGRAM - AN UPDATE
TED WIERZBANOWSKI and DAN MCCORRY (National Aero-Space Plane Joint Program Office, Wright-Patterson AFB, OH) IN: 1990 report to the aerospace profession; Society of Experimental Test Pilots, Symposium, 34th, Beverly Hills, CA, Sept. 27-29, 1990, Proceedings. Lancaster, CA, Society of Experimental Test Pilots, 1990, p. 117-133.
Copyright
The NASP Program has made substantial technical progress and undergone significant change since the last report to the Society in 1987. This paper will focus on the technical progress that has been made in the areas of propulsion, materials, computational fluid dynamics (CFD) validation, and overall design of the X-30. The impact that the flight test community has had on the approach to the development and test of the X-30 will also be included. A short discussion of the transition to a new management and program execution process through use of a National Contractor Team will also be presented along with the new revised schedule for the overall program. Author

A92-16150
NASA RESEARCH PROGRAM DIRECTED AT REDUCING SUPERSONIC TRANSPORT NOISE
EDWARD H. PHILLIPS Aviation Week and Space Technology (ISSN 0005-2175), vol. 135, Nov. 25, 1991, p. 69, 71, 72.
Copyright
An overview is presented of NASA's High Speed Research Program for studying advanced low-drag/high-lift systems, supersonic laminar flow control techniques, and innovative vehicle aerodynamics. The overall goals for the program center on three technology areas: effects of engine emissions on the atmosphere, ability to meet current FAA Stage 3 noise rules, and methods to minimize sonic boom. R.E.P.

A92-16675
RAH-66 COMANCHE - A CUT ABOVE THE REST
ORLIN L. MULLEN (U.S. Army, Washington, DC) Vertiflite (ISSN 0042-4455), vol. 37, Nov.-Dec. 1991, p. 13-15.
Copyright
A primary objective of the Comanche military helicopter's designers was the greatest possible maneuverability, in conjunction with a dash speed of over 170 kts. The vertical rate-of-climb achieved, at over 1000 ft/min (at 95 percent maximum power), represents unprecedented payload capacity and maneuverability. Combat survivability is achieved by a combination of long-range target acquisition by onboard sensors and passive signature-reduction techniques. The maintenance concept implemented incorporates built-in-test-and-test-equipment methods for onboard fault isolation. O.C.

A92-17095
AIR TRANSPORT RESEARCH IN GERMANY [LUFTFAHRTFORSCHUNG IN DEUTSCHLAND]
HEINZ MAX (DLR, Cologne, Federal Republic of Germany) Luft- und Raumfahrt (ISSN 0173-6264), vol. 12, Sept.-Oct. 1991, p. 22-25. In German.
Copyright
The medium-range research program being carried out by the German Research Institute for Aviation and Space Flight is discussed. This paper outlines the main areas of research being carried out in this program, including both rigid body aircraft and helicopters. C.D.

A92-17097
GERMAN AIRPORTS - CAPACITY CRISIS [DEUTSCHE FLUGHAEFEN - KAPAZITAETSKRISE]
Luft- und Raumfahrt (ISSN 0173-6264), vol. 12, Sept.-Oct. 1991, p. 40-45. In German.
Copyright
The capacity crisis at German airports is reviewed and possible solutions are addressed. The role of government planning and the conflict of interests between localities and the country as a whole are examined, and the legal framework for handling the capacity crisis is discussed. Needed reforms in transportation systems are considered, including near-term technical fixes and long-term solutions. C.D.

N92-12538# National Aerospace Lab., Amsterdam (Netherlands).
A KNOWLEDGE-BASED ASSISTANT FOR DIAGNOSIS IN AIRCRAFT MAINTENANCE
M. A. PIERS and J. C. DONKER *In* AGARD, Machine Intelligence for Aerospace Electronic Systems 7 p Sep. 1991
Copyright Avail: NTIS HC/MF A14; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive
A feasibility study on the application of knowledge based systems for diagnosis of complaints in aircraft systems is described. The specific application selected for the Knowledge-based Assistant for Diagnosis in Aircraft Maintenance (KADAM) Project is a knowledge based system to be used by ground engineers for troubleshooting of an aircraft air conditioning system. The approach is addressed, and the results, including the design of the proof-of-concept system, are reviewed. Particular attention is paid to the identification and formalization of methods for diagnosis. Author

N92-12988# Loughborough Univ. of Technology (England). Dept. of Transport Technology.
A REVIEW OF UK AVIATION POLICY
ROBERT CAVES Jul. 1991 47 p
(TT-9107; ISBN-0-904947-34-3; ETN-91-90293) Copyright
Avail: NTIS HC/MF A03
The background to present aviation policies is discussed and the U.K. (United Kingdom) aviation situation is reviewed. The main aviation issues are discussed in the light of this background. These issues come under the following headings: infrastructure capacity; role of regional airports; airport privatization; environment impact; resources; safety; security; economic regulation; EEC (Europnean Economic Community) harmonization; equal opportunity; general aviation; the civil aviation authority; aviation and the economy; integrated transport; planning methodology; policy formulation. Policy changes are suggested from a synthesis of discussions. ESA

N92-12989*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AN EXPERIMENTAL STUDY OF THE SENSITIVITY OF HELICOPTER ROTOR BLADE TRACKING TO ROOT PITCH ADJUSTMENT IN HOVER
W. KEATS WILKIE, CHESTER W. LANGSTON, PAUL H. MIRICK, JEFFREY D. SINGLETON, MATTHEW L. WILBUR, and WILLIAM T. YEAGER, JR. Dec. 1991 14 p
(Contract DA PROJ. 1L1-62211-A-47-AB)
(NASA-TM-4313; L-16939; NAS 1.15:4313;
AVSCOM-TR-91-B-017) Avail: NTIS HC/MF A03 CSCL 01/2
The sensitivity of blade tracking in hover to variations in root pitch was examined for two rotor configurations. Tests were

conducted using a four bladed articulated rotor mounted on the NASA-Army aeroelastic rotor experimental system (ARES). Two rotor configurations were tested: one consisting of a blade set with flexible fiberglass spars and one with stiffer (by a factor of five in flapwise and torsional stiffnesses) aluminum spars. Both blade sets were identical in planform and airfoil distribution and were untwisted. The two configurations were ballasted to the same Lock number so that a direct comparison of the tracking sensitivity to a gross change in blade stiffness could be made. Experimental results show no large differences between the two sets of blades in the sensitivity of the blade tracking to root pitch adjustments. However, a measurable reduction in intrack coning of the fiberglass spar blades with respect to the aluminum blades is noted at higher rotor thrust conditions. Author

N92-12991# General Accounting Office, Washington, DC. National Security and International Affairs Div.
AEROSPACE PLANE TECHNOLOGY: RESEARCH AND DEVELOPMENT EFFORTS IN JAPAN AND AUSTRALIA
Oct. 1991 153 p
(AD-A241641; GAO/NSIAD-92-5) Avail: NTIS HC/MF A08
CSCL 01/3

U.S. leadership and preeminence in the research and development of aerospace plane technologies are being challenged by Japan and other countries. U.S. leadership and preeminence are based on the National Aero-Space Plane Program. As discussed in our prior report on European aerospace plane technology, congressional supporters of the program are concerned about foreign competition and its impact on U.S. technological leadership. The former Chairman of the House Committee on Science, Space, and Technology asked GAO to identify indicators to measure foreign countries' current state of aerospace plane technological development and progress. The indicators were selected based on the interests of Committee representatives and on discussions with experts. These indicators are (1) space policies and aerospace goals and objectives; (2) aerospace plane program objectives, design goals, schedules, and costs; (3) the current status and rate of progress in the development of critical technologies; (4) the funding for and the number and type of people involved with the programs; (5) test facilities and their capabilities; and (6) the existence of and interest in international cooperation. The former Chairman also asked GAO to collect data and information on the indicators. GRA

N92-12992# Naval Postgraduate School, Monterey, CA.
IMPLEMENTING TOTAL QUALITY MANAGEMENT AT THE INTERMEDIATE LEVEL OF AIRCRAFT MAINTENANCE M.S. Thesis
ROLANDO C. SALVANERA Dec. 1990 64 p
(AD-A241768) Avail: NTIS HC/MF A04 CSCL 05/2

This thesis will show how Total Quality Management (TQM) can be taken from theory and operationalized at the intermediate level of aircraft maintenance. It begins by presenting four factors that will support the implementation process: top level commitment in the form of CNO support; the closed loop environment of intermediate maintenance activities; the successful implementation at the depot level; and the fact that components of TQM already exist within the Navy. The thesis then introduced some of the resource centers that can assist with the implementation process. The methods of TQM implementation as advocated by Navy Resource Centers (the Navy Personnel Research and Development Center and the Naval Aviation Maintenance Office) are explored. The thesis illustrates how the use of these resource centers, the early targeting of key personnel, and the use of a pilot program can help facilitate the implementation process. An examination of the obstacles to the TQM implementation process such as adapting existing programs and reward systems, conclude the thesis. GRA

02

AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

A92-13300
EXPERIMENTAL INVESTIGATION ON GAS-PARTICLE FLOW IN CASCADES
JINGHAI YI and CAIFEN MA (Xian Jiaotong University, Xian, People's Republic of China) Journal of Engineering Thermophysics (ISSN 0253-231X), vol. 12, Aug. 1991, p. 279-282. In Chinese.

Detailed measurements are made for three inlet attack angles, i = -10 deg, 0 deg, and 10 deg, and for two mass concentrations, alpha = 0 and 0.07 percent. Results show that, with an increase in attack angle i, the pressure distribution on the pressure side rises, outlet flow angle decreases, and wake deviation appears. Author

A92-13448
SECONDARY SEPARATION FROM A SLENDER WING
K. KIRKKOPRU and N. RILEY (East Anglia, University, Norwich, England) Journal of Engineering Mathematics (ISSN 0022-0833), vol. 25, Nov. 1991, p. 329-352. Research supported by Ministry of Defence Procurement Executive. refs
Copyright

The high Reynolds number laminar flow of an incompressible fluid past a slender delta wing at incidence is considered. The primary separation is represented by vortex sheets emanating from the leading edges. These sheets also carry a source distribution to represent viscous displacement effects. An interactive viscous-inviscid calculation is carried out to determine the secondary-separation flow properties on the wing. Agreement between the theoretical predictions and experiment is encouraging. For example, unlike the purely inviscid calculations, there is only a small pressure recovery beyond the suction peak, as is observed in experiment. Similarly, the upward and inboard movement of the vortex core due to the secondary separation is in accord with experiment, as is the position of secondary separation. Author

A92-13673
AIRFOIL BOUNDARY LAYER MEASUREMENTS AT LOW RE IN AN ACCELERATING FLOW FROM A NONZERO VELOCITY
R. H. ELLSWORTH (Rockwell Space Operations Co., Houston, TX) and T. J. MUELLER (Notre Dame, University, IN) Experiments in Fluids (ISSN 0723-4864), vol. 11, no. 6, Oct. 1991, p. 368-374. refs
(Contract N00014-83-K-0239)
Copyright

The effects of an accelerating freestream from a nonzero velocity on the transitional separation bubble characteristics have been studied. The boundary layer velocity profile response to the acceleration at selected chordwise locations on an airfoil at 7 deg angle of attack was determined using hot wire anemometry. The purpose of the present experiment was to verify the results of previous research on a sinusoidally oscillating freestream velocity by uncoupling the accelerating and decelerating boundary layer effects. Data obtained indicate that as a result of a freestream acceleration, the separation bubble position shifts in the direction opposite to the chordwise direction in which it would move for a quasi-steady velocity change. The transition location is found to be more responsive to the acceleration than the separation position. O.G.

A92-13690
EXTENSION OF A THREE-DIMENSIONAL EULER METHOD FOR CALCULATING THE FLOWFIELD AROUND BYPASS ENGINES WITH FAN AND CORE JET [ERWEITERUNG EINES DREIDIMENSIONALEN EULER-VERFAHRENS ZUR BERECHNUNG DES STROEMUNGSFELDES UM NEBENSTROMTRIEBWERKE MIT FAN- UND KERNSTRAHL]

R. RUDNIK (DLR, Institut fuer Entwurfsaerodynamik, Brunswick, Federal Republic of Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 15, Oct. 1991, p. 285-288. In German. refs
Copyright

The present communication is concerned with a numerical investigation of the flowfield around bypass engines. The solution method is based on a finite volume discretization of the 3D Euler-equations for compressible, inviscid flows. A brief survey of the grid generation method and the solution algorithm is given with special regard to the boundary conditions for the engine simulation. Realistic operational engine conditions are calculated by taking into account the fan inlet mass flow, the pressure and total temperature ratio of the jet. As an example for a flow calculation an investigation of a high bypass engine under cruise and low-speed conditions is discussed. Author

A92-13741
HEAT TRANSFER IN SUPERSONIC FLOW PAST A SINGLE CRATER [TEPLOOBMEN PRI SVERKHZVUKOVOM OBTEKANII ODINOCHNOI LUNKI]
V. IA. BOROVOI and L. V. IAKOVLEV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Sept.-Oct. 1991, p. 48-52. In Russian. refs
Copyright

Flow and heat transfer on a plate with a single crater is investigated experimentally for free-stream Mach 4 and a Reynolds number of 3.6 x 10 exp 6. The flow pattern near the crater is determined, and regions with increased heat transfer are identified. Heat transfer coefficients are determined inside the crater and near it. It is shown that a single crater has practically no effect on the integral heat flux. V.L.

A92-13748
CALCULATION OF THE BASE PRESSURE AND ENTHALPY BEHIND A STEP IN THE PATH OF TWO SUPERSONIC STREAMS WITH ALLOWANCE FOR THE EFFECT OF BOUNDARY LAYERS AND HEAT FLUXES [RASCHET DONNOGO DAVLENIIA I ENTAL'PII ZA USTUPOM, OBTEKAEMYM DVUMIA SVERKHZVUKOVYMI POTOKAMI, S UCHETOM VLIIANIIA POGRANICHNYKH SLOEV I TEPLOVYKH POTOKOV]
V. K. MASALOV and R. K. TAGIROV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Sept.-Oct. 1991, p. 167-176. In Russian. refs
Copyright

A relatively simple method is proposed for calculating flow parameters behind a step in the path of two supersonic streams. The method employs the boundary layer approximation and integral mass and energy conservation laws (a viscous-nonviscous interaction model). The method makes it possible to determine the base pressure and the base enthalpy with allowance for the effect of Mach numbers, Reynolds numbers, initial boundary layer thickness, adiabatic exponent, and wall enthalpies for different ratios of the integral pressures and enthalpies of the two streams. V.L.

A92-13749
EXPERIMENTAL STUDIES OF THE INTERACTION OF CONVERGING AXISYMMETRIC SHOCK WAVES WITH SHARP AND BLUNT CONES IN SUPERSONIC FLOW [EKSPERIMENTAL'NYE ISSLEDOVANIIA VZAIMODEISTVIIA SKHODIASHCHIKHSIA OSESIMMETRICHNYKH UDARNYKH VOLN S OSTRYM I PRITUPLENNYM KONUSAMI V SVERKHZVUKOVOM POTOKE]
A. V. KRASIL'NIKOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Sept.-Oct. 1991, p. 177-182. In Russian. refs
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Interactions of converging shock waves with sharp and blunt cones were investigated experimentally in a supersonic wind tunnel at a free-stream Mach of 4.67. Details of the experimental procedure and test results are discussed with emphasis on the effect of the taper angle of the converging shock wave, model shape, and its position relative to the shock wave configuration on flow structure and pressure distribution on the model surface. V.L.

A92-13815
INFLUENCE OF THE ENTROPY LAYER ON THE SEPARATION LENGTH IN HYPERSONIC AERODYNAMICS IN THE TRIPLE-DECK FRAMEWORK. II [INFLUENCE DE LA COUCHE D'ENTROPIE SUR LA LONGUEUR DE SEPARATION EN AERODYNAMIQUE HYPERSONIQUE, DANS LE CADRE DE LA TRIPLE COUCHE. II]
PIERRE-YVES LAGREE (Paris VI, Universite, France) Academie des Sciences (Paris), Comptes Rendus, Serie II - Mecanique, Physique, Chimie, Sciences de la Terre et de l'Univers (ISSN 0764-4450), vol. 313, no. 9, Oct. 24, 1991, p. 999-1004. In French. refs
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Inviscid-viscous interaction on a flat blunt plate in a weak hypersonic regime is examined on the triple-deck scales to delineate the influence of an asymptotically small nose bluntness on the flow structure near a laminar separation. The entropy layer scale is considered to be very small compared to that of the upper deck. The crude chemical effect and nose bluntness are accounted for by modifying the usual pressure-displacement relation. R.E.P.

A92-13816
A SIMPLIFIED MODEL FOR AERODYNAMIC FLOWS AROUND STREAMLINED MODELS [UN MODELE SIMPLIFIE POUR LES ECOULEMENTS AERODYNAMIQUES AUTOUR DE MAQUETTES ELANCEES]
PHILIPPE DESTUYNDER, PHILIPPE DUPUY, and FRANCOISE SANTI (Conservatoire National des Arts et Metiers, Saint-Cyr-l'Ecole, France) Academie des Sciences (Paris), Comptes Rendus, Serie II - Mecanique, Physique, Chimie, Sciences de la Terre et de l'Univers (ISSN 0764-4450), vol. 313, no. 9, Oct. 24, 1991, p. 1005-1010. In French. refs
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By utilizing an asymptotic technique based on a small parameter representing the slenderness of a vehicle, a simplified CFD model is developed. This model comprises three weakly coupled equations of which the first is a one-dimensional convection model in the main flow direction. The two other coupled equations represent a diffusion phenomenon through the cross-sections of the flow. R.E.P.

A92-14031
STEP RESPONSE OF UNSTEADY AERODYNAMICS ACTING ON A PLANE SWEPT WING IN INCOMPRESSIBLE FLOW FOR FINITE STATE MODELING
SHINJI SUZUKI and KOSYU KADOTA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 39, no. 452, 1991, p. 478-484. In Japanese. refs

The approximation of unsteady aerodynamic forces acting on a plane swept wing in the time domain is considered. Time responses of the aerodynamic forces caused by a step movement of a wing in incompressible flow are calculated using the time-domain vortex element method. It was found that transient characteristics of the step responses associated with a certain generalized aerodynamic force can be represented by one decreasing function regardless of wing motions. By approximating each decreasing function with a set of exponential functions and by calculating apparent mass coefficients and steady state forces, a mathematical model for the aerodynamic forces in the form of first-order linear time-invariant differential equations (the state equations) is obtained. The accuracy and the applicability of the method have been confirmed through the comparison between the approximated aerodynamic forces and the unsteady forces calculated directly in the time-domain or measured experimentally. Author

A92-14033
FINITE DIFFERENCE NUMERICAL PREDICTION OF AERODYNAMICS OF AN AIRFOIL FLYING OVER WAVY WALL
KYOKO NITTA, SHIGENORI ANDO, and HIROYUKI WAKU Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 39, no. 452, 1991, p. 491-495. In Japanese. refs

The lift on an airfoil flying over a wavy wall surface is calculated using a finite difference method which was developed by Nakamichi to improve LTRAN2 evolved by Ballhaus and Goorjian. Numerical computations include cases of a flat plate over a flat solid wall prior to the cases of a moving wavy wall. Modification of grid generating system is the major point for applying the LTRAN2 version to the present problem. Weak compressibility is considered but nonlinearity is neglected in the calculations. The calculated results are compared with those obtained by the lifting surface theory of Ichikawa et al. The agreement is quite satisfactory.
Author

A92-14071
ON VORTEX INTERFERENCE FOR CANARD CONFIGURATION
BINQIAN ZHANG and YONGNIAN YANG (Northwestern Polytechnical University, Xian, People's Republic of China) Northwestern Polytechnical University, Journal (ISSN 1000-2758), vol. 9, Oct. 1991, p. 433-437. In Chinese. refs

An examination is made of the vortex-interference problem associated with a close-coupled canard configuration employing forward-swept wings (FSWs). Flow visualization and water tunnel vortex measurements are used to characterize the mechanism responsible for the postponement of wing leading-edge vortex breakdown. The canard vortex has an entraining effect on the low-energy separated flow at the FSWs' roots. The leading-edge vortex of the FSW can be strengthened, and its breakdown position moved substantially rearward, due to the side-wash effect of the canard's reverse vortex. Canard deflections which intensify its trailing vortex also strengthen the abovementioned effects. O.C.

A92-14280
FUNDAMENTALS OF APPLIED AEROGASDYNAMICS. I - AERODYNAMICS OF WINGS (PROFILES), AIRFRAMES, AND THEIR COMBINATIONS [OSNOVY PRIKLADNOI AEROGAZODINAMIKI. I - AERODINAMIKA KRYLA /PROFILIA/, KORPUSA I IKH KOMBINATSII]
NIKOLAI F. KRASNOV, EVGENII E. BOROVSKII, and ALEKSANDR I. KHLUPNOV Moscow, Izdatel'stvo Vysshaia Shkola, 1990, 336 p. In Russian. refs
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Analytical and numerical methods for determining the parameters of nonviscous gas flow around bodies are reviewed. Algorithms and computer programs are presented for calculating the aerodynamic derivatives and the drag of isolated wings (profiles), airframes, and their combinations. The aerodynamic characteristics of control surfaces are determined in the general case of steady flow. V.L.

A92-14281
FUNDAMENTALS OF APPLIED AEROGASDYNAMICS. II - VISCOUS FLOW PAST BODIES. CONTROL DEVICES [OSNOVY PRIKLADNOI AEROGAZODINAMIKI. II - OBTEKANIE TEL VIAZKOI ZHIDKOST'IU. RULEVYE USTROISTVA]
NIKOLAI F. KRASNOV, VSEVOLOD N. KOSHEVOI, VADIM F. ZAKHARCHENKO, and ANATOLII N. DANILOV Moscow, Izdatel'stvo Vysshaia Shkola, 1991, 360 p. In Russian. refs
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Analytical and numerical methods are presented for calculating the boundary layer (laminar, turbulent, and mixed), heat transfer, aerodynamic heating, and ablation. Separated and jet flows are analyzed as means of controlling flow around bodies and their aerodynamic characteristics. Data are presented on the automation of an aerodynamic experiment using a computer for data acquisition, processing, and storage. Algorithms and programs are also presented for computing the parameters of viscous gas flow and separated flows and for calculating the design parameters of wind tunnels. V.L.

A92-14328* Georgia Inst. of Tech., Atlanta.
AN INTEGRATED AIRLOADS-INFLOW MODEL FOR USE IN ROTOR AEROELASTICITY AND CONTROL ANALYSIS
DAVID A. PETERS (Georgia Institute of Technology, Atlanta) and AY SU IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 25-40. Research sponsored by U.S. Army and NASA. refs
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The airloads-inflow model presented is ideally suited for rotor aeroelasticity and control analysis, especially where eigenvalues are sought. The model, which is derived from thin-airfoil theory with an extension that allows for other airfoil effects, is of hierarchical-lift type and may be simplified to any degree desired; the inflow is also expanded in shape functions which may be truncated to any desired texture. Both models are written in closed-form, state-variable equations without hidden states and without integrals over the wake. O.C.

A92-14329
THREE DIMENSIONAL ANALYSIS OF A ROTOR IN FORWARD FLIGHT
R. G. RAJAGOPALAN (Iowa State University of Science and Technology, Ames) and SANJAY R. MATHUR IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 41-63. Research supported by Iowa State University of Science and Technology. refs
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The present solution of the steady incompressible laminar Navier-Stokes equations in Cartesian coordinates for the flow characteristics of a helicopter rotor in forward flight employs a modeling of the rotor in terms of momentum sources. These sources' magnitudes are ascertained from implicit functional relations involving flowfield, rotor geometry, and blade cross-section aerodynamics. No assumptions are made about the wake structure. Experimentally obtained blade-loads are compared with experimental results. Solutions are presented for the near and far wake flowfields. O.C.

A92-14330* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
WING TIP VORTEX CALCULATIONS WITH AN UNSTRUCTURED ADAPTIVE-GRID EULER SOLVER
ROGER C. STRAWN (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 65-76. refs
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A solution-adaptive grid method has been developed for computing tip-vortex flowfields around rectangular wings. This method uses subdivision in order to locally refine the grid in regions with high vorticity. Two different flow solvers are used. Each solves the three-dimensional Euler equations on unstructured grids. Computed results are compared to experimentally measured surface pressures and vortex velocities on a NACA 0015 rectangular wing. Predicted results for surface pressures and integrated lift agree well with the experimental data. The predicted size of the rotational vortex core is larger than the experimentally-measured value and the peak velocities are less. This discrepancy appears to be caused by deficiencies in the inviscid Euler-equation model. This model cannot capture the complex viscous effects at the tip that determine the detailed structure of the resulting vortex. In spite of this limitation, the present Euler unstructured adaptive-grid method demonstrates the ability to convert vortical flows with low numerical diffusion. Applications for modeling helicopter rotor wake systems are discussed. Author

A92-14358
FUNDAMENTAL RESEARCH IN HELICOPTER ROTOR BLADE-VORTEX INTERACTION MODELING
DAVID R. POLING (Boeing Defense and Space Group, Helicopters Div., Philadelphia, PA), MICHAEL C. WILDER, and DEMETRI P. TELIONIS (Virginia Polytechnic Institute and State University, Blacksburg) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, *Proceedings. Vol. 1. Alexandria, VA, American Helicopter* Society, 1991, p. 421-433. refs

To improve the understanding of flow phenomena involved in helicopter rotor vibration and noise, blade-vortex interactions (BVI) were investigated analytically and experimentally by modeling two dimensional vortex encounters with an airfoil section. Analytically, the unsteady flow and its interaction with a lifting airfoil were calculated using a scheme which employs conformal transformations and clusters of discrete vortices. In the laboratory, a pitching NACA 0012 was used to generate vortices which interact with a 'target' airfoil positioned downstream. Measurements using Laser Doppler Velocimetry (LDV) were obtained in the flow field surrounding the target airfoil. The instantaneous chordwise pressures calculated by analysis were compared to the experimental data and found to be in good qualitative and quantitative agreement. The flow field measurements, reported here, provide an insight into the mechanism of blade-vortex interaction effects and are sufficiently detailed to be the data base for the validation of computational fluid dynamics methods by which practical BVI alleviation concepts can be defined. Author

A92-14359
AN ANALYSIS OF PITCH AND PLUNGE EFFECTS ON UNSTEADY AIRFOIL BEHAVIOR
JOSEPH C. TYLER and J. G. LEISHMAN (Maryland, University, College Park) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, *Proceedings. Vol. 1. Alexandria, VA, American Helicopter* Society, 1991, p. 435-450. refs
(Contract DAAL03-88-C-0002)

An analysis is conducted into the effects of pitch forcing versus plunge forcing on unsteady airfoil behavior. Experimental data are analyzed in conjunction with unsteady airfoil theory and a semi-empirical model for dynamic stall. By considering the contributions to the unsteady airloads due to angle of attack versus pitch rate, this study addresses the effects of different types of forcing on the steady airloads, including the factors that govern aerodynamic damping, the onset of leading edge separation, and dynamic stall. Author

A92-14360
A 3-D SEPARATION MODEL FOR ARBITRARY PLANFORMS
T. S. BEDDOES (Westland Helicopters, Ltd., Yeovil, England) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 451-460. refs

A method is presented for the simulation of flow separation on lifting surfaces in three dimensions. The procedure is implemented using three modules which have been developed for incorporation in a rotor loads program. These consist of an indicial formulation of time dependent lift and moment for attached flow, a separation degree of freedom and a near wake model. Interaction between these modules is effected in a time stepping mode which is capable of reproducing either dynamic response or steady state conditions. A simplification of the treatment of the center section of swept wings is extended to accommodate wings with arbitrary changes in planform and sweep. Validity of the approach is evaluated by comparisons with experiment and theory using planforms of increasing complexity, comprising rectangular, tapered and swept and finally utilizing the tip planform of the BERP rotor. There are implications for the design of advanced tip planforms where the nonlinear behavior may be used to advantage. Author

A92-14362* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
HELICOPTER LOCAL BLADE CIRCULATION CALCULATIONS FOR A MODEL ROTOR IN FORWARD FLIGHT USING LASER VELOCIMETER MEASUREMENTS
DANNY R. HOAD (NASA, Langley Research Center, Hampton, VA) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, *Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society,* 1991, p. 487-501. refs

A program is described whose purpose was to develop the measurement and data processing techniques necessary to accurately compute the local rotor blade circulation at any azimuth and radius in a wind tunnel environment at representative forward speeds. With these techniques, further tests using a complex rotor system with local surface pressure measurements should help to determine the accuracy of the technique for general applications to rotor blade span-load measurement programs in wind tunnel forward flight conditions. Preliminary calculations are reported. Author

A92-14407* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ONGOING DEVELOPMENT OF A COMPUTER JOBSTREAM TO PREDICT HELICOPTER MAIN ROTOR PERFORMANCE IN ICING CONDITIONS
RANDALL K. BRITTON (NASA, Lewis Research Center, Cleveland; Sverdrup Technology, Inc., Brook Park, OH) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 1119-1126. Previously announced in STAR as N91-19056. refs
(Contract NAS3-25266)

Work is currently underway at the NASA Lewis Research Center to develop an analytical method for predicting the performance degradation of a helicopter operating in icing conditions. A brief survey is performed of possibilities available to perform such a calculation along with the reasons for choosing the present approach. A complete description of the proposed jobstream is given as well as a discussion of the present state of the development. Author

A92-14424
LIFTING LINE PREDICTIONS FOR A SWEPT TIP ROTOR BLADE
COLIN YOUNG (Royal Aerospace Establishment, Farnborough, England), WILLIAM G. BOUSMAN, THOMAS H. MAIER (U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA), FRANCOIS TOULMAY (Aerospatiale, Marignane, France), and NEIL GILBERT (Defence Science and Technology Organisation, Aeronautical Research Laboratory, Melbourne, Australia) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 1345-1370. refs

Four lifting line analyses have been used to calculate the airloads and blade stresses on a swept tip helicopter rotor tested in flight. The capability of the analyses is assessed over a range of advance ratios from low speed flight, where the wake modeling is important, to high speed conditions, where the representation of the blade dynamics and unsteady aerodynamic effects are the dominant features. Author

A92-14428
COMPARISON OF THEORY AND EXPERIMENT FOR NONLINEAR FLUTTER AND STALL RESPONSE OF A HELICOPTER BLADE
D. M. TANG and E. H. DOWELL (Duke University, Durham, NC) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 1413-1425. refs
(Contract DAAL03-87-K-0023)

The purpose of the present paper is to study the flutter instability and forced response of a non-rotating helicopter blade model with parabolic and freeplay torsional stiffness nonlinearity based upon the (linear and) nonlinear ONERA stall aerodynamic model. An experiment has also been carried out in the Duke University low speed wind tunnel. The wind tunnel tests show good agreement between theory and experiment for linear and nonlinear flutter instability; for periodic, limit cycle and chaotic flutter motion and forced response behavior; and for the effects of initial disturbance on nonlinear flutter instability. Comparisons of the results of the theory and the experiment are helpful in understanding physically the nonlinear aeroelastic phenomena and chaotic oscillations.
Author

A92-14446
A RE-EXAMINATION OF THE AERODYNAMICS OF HOVERING ROTORS INCLUDING THE PRESENCE OF THE FUSELAGE
DAVID R. CLARK and BRIAN MASKEW (Analytical Methods, Inc., Redmond, WA) AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Paper. 12 p. refs
(Contract DAAL03-89-C-0003)
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The paper describes the application of a second generation, low-order, panel method operating in the time domain to the calculation of the flow around a hovering rotor in the presence of a body. The method is described and some correlation with experimental data is presented. Agreement between calculated and measured results is generally good. Author

A92-15031
INFLUENCE OF THREE-DIMENSIONAL EFFECTS ON HYDRODYNAMICS AND HEAT TRANSFER IN SUBSONIC FLOW OF A VISCOUS COMPRESSIBLE GAS IN THE INITIAL SECTION OF A RECTANGULAR DUCT [O VLIIANII TREKHMERNYKH EFFEKTOV NA GIDRODINAMIKU I TEPLOOBMEN PRI DOZVUKOVOM TECHENII VIAZKOGO SZHIMAEMOGO GAZA NA NACHAL'NOM UCHASTKE KANALA PRIAMOUGOL'NOGO SECHENIIA]
A. E. KUZNETSOV, M. KH. STRELETS, and M. L. SHUR (NPO Gosudarstvennyi Institut Prikladnoi Khimii, Leningrad, USSR) Teplofizika Vysokikh Temperatur (ISSN 0040-3644), vol. 29, Sept.-Oct. 1991, p. 967-972. In Russian. refs
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The influence of three-dimensional effects on hydrodynamics and heat transfer in the initial section of a heated rectangular duct is investigated numerically for Mach numbers at the duct inlet ranging from 0 to 0.3 and Reynolds numbers 50-150. The analysis is based on a full stationary system of Navier-Stokes equations. It is shown, in particular, that the effect of flow compressibility on the principal flow characteristics becomes significant when maximum local Mach numbers reach about 0.6.
V.L.

A92-15327
TRANSIENT AERODYNAMIC BEHAVIOURS ASSOCIATED WITH STEPWISE INCIDENCE VARIATION OF AIRFOILS
Y. AIHARA, H. KOYAMA, E. AKASHI (Tokyo, University, Japan), and HUIZHONG YAO (Nanjing Aeronautical Institute, People's Republic of China) Chinese Journal of Aeronautics (ISSN 1000-9361), vol. 4, May 1991, p. 99-103. refs
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Transient aerodynamic characteristics of airfoil are important for the safety of airplanes, the development of helicopter rotors, and many other applications of unsteady aerodynamics. For a better understanding of these phenomena, it is necessary to investigate the simultaneous relation between the characteristics and the flowfield. The purpose of the present study is to clarify experimentally the fundamentals of the aerodynamic behaviors associated with stepwise incidence variations from 0 to some certain values, including high angles of attack, of symmetric airfoils at low speeds, Reynolds number of the order of 10 exp 4. Temporal variations of surface pressure distribution, lift, drag and pitching moment, and the observations of the flowfield are discussed.
Author

A92-15335
INVESTIGATION OF UNSTEADY EXCITATION EFFECTS ON AERODYNAMIC PROPERTIES OF AIRFOILS
E. J. CUI, G. M. FU, and X. T. YU (Beijing Institute of Aerodynamics, People's Republic of China) Chinese Journal of Aeronautics (ISSN 1000-9361), vol. 4, May 1991, p. 163-170. Research supported by NNSFC. refs
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Techniques to manage and control flow over airfoils by using external unsteady excitations are investigated. The mechanisms of these excitation effects are also explored. The principal goal of this study is to gain a better understanding and to find the possible ways for enhancing aerodynamic efficiency. The experimental investigations are carried out in two low-speed wind tunnels. The test models are two dimensional airfoils with different section geometries. The emphasis is placed only on the 'dynamic amplifying effects' on aerodynamic lift. Results obtained indicate that the beneficial aerodynamic effects of section lift increase can be obtained at the high angle of attack near stall regime, as long as the frequency and amplitude of the excitation are appropriately selected. Author

A92-15344* Tennessee Univ. Space Inst., Tullahoma.
REVIEW OF THE PHYSICS OF ENHANCING VORTEX LIFT BY UNSTEADY EXCITATION
J. Z. WU, A. D. VAKILI, and J. M. WU (Tennessee, University, Tullahoma) Progress in Aerospace Sciences (ISSN 0376-0421), vol. 28, no. 2, 1991, p. 73-131. refs
(Contract NAG1-844)
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A review aimed at providing a physical understanding of the crucial mechanisms for obtaining super lift by means of unsteady excitations is presented. Particular attention is given to physical problems, including rolled-up vortex layer instability and receptivity, wave-vortex interaction and resonance, nonlinear streaming, instability of vortices behind bluff bodies and their shedding, and vortex breakdown. A general theoretical framework suitable for handling the unsteady vortex flows is introduced. It is suggested that wings with swept and sharp leading edges, equipped with devices for unsteady excitations, could yield the first breakthrough of the unsteady separation barrier and provide super lift at post-stall angle of attack. O.G.

A92-15345
A REVIEW OF RIGID BODY RESPONSE ON STING SUPPORTED MODELS AT HIGH ANGLES OF INCIDENCE
D. G. MABEY, B. L. WELSH, and C. R. PYNE (Royal Aerospace Establishment, Bedford, England) Progress in Aerospace Sciences (ISSN 0376-0421), vol. 28, no. 2, 1991, p. 133-170. refs
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The new requirement to test wind tunnel models of combat aircraft at high angles of incidence and high kinetic pressures has led to a review of the factors controlling model stability. Dangerous motions might occur on models at high angles of incidence unless special preventive measures are taken. An internal tuned damper and balance bump stops are recommended to limit the responses. The bump stops prevent the moment limits of the strain gauge balance from being exceeded. The effectiveness of both devices was confirmed by tests on a swept wing model which experienced dangerous bending oscillations in a vertical plane at a Mach number of 0.50 in the incidence range from about 27-29 deg together with dangerous yawing oscillations in a horizontal plane above an incidence of about 35 deg. Author

A92-15356
COMPUTATION OF THE POTENTIAL FLOW THROUGH CASCADES USING THE CONFORMAL MAPPING AND THE SINGULARITY METHOD
SHUJI TANAKA, SUSUMU MURATA (Toyota Technological Institute, Nagoya, Japan), and KAZUO KURATA (Yanmar Diesel

Co., Ltd., Osaka, Japan) JSME International Journal, Series II (ISSN 0914-8817), vol. 34, Nov. 1991, p. 423-430. refs
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A numerical analysis of a 2D incompressible potential flow through cascades of airfoils with arbitrary profiles is presented. An airfoil row in the physical plane is first transformed into a near-circle row using a simple mapping function, and then the singularity method is applied in the mapped plane. A cascade of thin or practical airfoils can be transformed into a near-circle row with sufficiently smooth contour through the proposed procedure. The results are found to be in good agreement with the exact solutions for a cascade of flat plates or specified airfoils by Gostelow, in which the numerical error for the typical cascade configuration is as low as 0.2 percent. O.G.

A92-15359
FLOW UNSTEADINESS BY WEAK NORMAL SHOCK WAVE/TURBULENT BOUNDARY LAYER INTERACTION IN INTERNAL FLOW

HEUY-DONG KIM, KAZUYASU MATSUO, SHIGETOSHI KAWAGOE (Kyushu University, Fukuoka, Japan), and TETSUHIKO KINOSITA (Toshiba Corp., Yokohama, Japan) JSME International Journal, Series II (ISSN 0914-8817), vol. 34, Nov. 1991, p. 457-465. refs
Copyright

The unsteadiness caused by the interaction of a weak normal shock wave with a turbulent boundary layer in a supersonic diffuser was investigated experimentally. It is found that the intermittent feature of the unsteady shock motion is similar to that in external flows and that the maximum standard deviations correspond to points where the intermittency factor approaches 0.5 and are significantly influenced by the flow separation. It is shown that far downstream from the shock wave/turbulent boundary layer interaction region the amplitude of pressure fluctuations is nearly independent of the flow Mach number. O.G.

A92-15487
REALIZATION OF A LARGE-SCALE TURBULENCE FIELD IN A SMALL WIND TUNNEL

HIDEHARU MAKITA (Toyohashi University of Technology, Japan) Fluid Dynamics Research (ISSN 0169-5983), vol. 8, Oct. 1991, p. 53-64. refs
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An active turbulence generator was developed to generate a large-scale turbulence having large turbulence Reynolds numbers in a small wind tunnel. The statistical quantities were measured in the resultant homogeneous and quasi-isotropic turbulence. High turbulence intensities and large integral scales were attained in it. The energy spectrum had a wide inertial subrange of about two orders of magnitude in wavenumber. The width of the inertial subrange approached that obtained for the grid turbulence having a far larger mesh Reynolds number of 2.4 x 10 exp 6. Intermittency of fine-scale turbulent eddies was observed in the waveform of the velocity derivative. Author

A92-15503
COMPUTATIONAL STUDY OF STALL FLUTTER IN LINEAR CASCADES

A. ABDEL-RAHIM, F. SISTO, and S. THANGAM (Stevens Institute of Technology, Hoboken, NJ) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 9 p. refs
(ASME PAPER 91-GT-5)

A computational scheme based on the vortex method is used to simulate the flow over a linear cascade of airfoils. The preliminary structural model is a two-dimensional characteristic section with a single degree of freedom in either bending or torsion. A study of the relationship between the stall propagation frequency and the blade natural frequency has been conducted. The study shows that entrainment, or frequency synchronization, occurs, resulting in pure torsional flutter over a certain interval of reduced frequency. A severe blade torsional amplitude (of order 20 deg) has been computed in the entrainment region reaching its largest value in the center of the interval. Outside the entrainment interval, the stall propagation is shown to be independent of the blade natural frequency. In addition, computational results show that there is no entrainment in the pure bending mode. Rather, 'de-entrainment' occurs with similar flow conditions and similar stall frequencies, resulting in blade buffeting in pure bending. Author

A92-15505
EXPERIMENTAL STUDY OF THE SWIRLING FLOW IN THE INTERNAL VOLUTE OF A CENTRIFUGAL COMPRESSOR

E. AYDER and R. VAN DEN BRAEMBUSSCHE (Von Karman Institute for Fluid Dynamics, Rhode-Saint-Genese, Belgium) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. Research supported by Atlas Copco Airpower. refs
(ASME PAPER 91-GT-7)

A detailed study of the swirling flow in a rectangular volute of a centrifugal compressor is presented. The 3D flowfield has been measured by means of a five-hole probe at six different cross sections for three different operating points of the compressor. For high mass flow, the large radial velocity component at the diffuser exit creates a strong swirling flow with a forced vortex type of velocity distribution. The centrifugal force resulting from this motion is balanced by the increase of static pressure from the swirl center to the volute wall. Less swirl is generated for optimum mass flow resulting in smaller pressure gradients over the cross section. For low mass flow, a large region of separated flow is observed, and more uniform static pressure has been measured over the cross section. Author

A92-15509
DESIGN METHOD FOR SUBSONIC AND TRANSONIC CASCADE WITH PRESCRIBED MACH NUMBER DISTRIBUTION

O. LEONARD and R. A. VAN DEN BRAEMBUSSCHE (Von Karman Institute for Fluid Dynamics, Rhode-Saint-Genese, Belgium) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. refs
(ASME PAPER 91-GT-18)

An iterative blade design procedure is presented which uses a time marching scheme to solve the unsteady Euler equations in the blade-to-blade plane. During the flow calculation, the required Mach number distribution is imposed in terms of static pressure directly on a permeable blade wall. Examples of both subsonic and transonic flow calculations show a rapid convergence to the geometry required for the desired Mach number distribution. With the present method, the same code can be used for both the design and the analysis of a blade. V.L.

A92-15514
STATOR AVERAGED, ROTOR BLADE-TO-BLADE NEAR WALL FLOW IN A MULTISTAGE AXIAL COMPRESSOR WITH TIP CLEARANCE VARIATION

I. N. MOYLE, G. J. WALKER, and R. P. SHREEVE (U.S. Naval Postgraduate School, Monterey, CA) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 9 p. Research supported by U.S. Navy. refs
(ASME PAPER 91-GT-30)

This paper describes the effect of tip clearance changes on the pressure at the case wall of a second stage rotor. Wall shear distributions under the rotor tip are also presented. The results show low pressure areas extending along the rotor suction side but lying away from the blade. Pressure contours indicate the tangential loading at the tip is lower than predicted by two-dimensional calculations, however, the predicted loading is observed between the lowest pressure's path in the passage and the blade pressure side. The results suggest a viscous or shearing layer, due to blade-to-wall relative motion, is generated on the blade side of the tip gap which modifies the inviscid relative flowfield and produces an unloading on the blade tip. Author

A92-15515
SURGE DYNAMICS IN A FREE-SPOOL CENTRIFUGAL COMPRESSOR SYSTEM
D. A. FINK (GE Aircraft Engines, Lynn, MA), N. A. CUMPSTY (Cambridge, University, England), and E. M. GREITZER (MIT, Cambridge, MA) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 12 p. Research supported by Cummins Engine Co. and USAF. refs
(ASME PAPER 91-GT-31)

Turbocharger surge has been investigated in a radial impeller-vaneless diffuser free-spool system. Several different aspects are addressed. First, two very different compression systems, one with a large downstream volume and one with the smallest possible downstream volume, are employed to examine stall initiation phenomena as well as the behavior of the compressor characteristics when operating in surge. The measurements show impeller stall at the inducer tips to be a key phenomenon in initiating surge. The inducer stall is stationary and asymmetric, due to the presence of the volute, and is most severe near the volute tongue angular position. The compressor characteristic in the large volume system (which gave surge) is observed to be flatter and to lag that in the stabilized small volume system. A nonlinear simulation of the system is also presented. Author

A92-15533
TURBINE CASCADE CALCULATIONS THROUGH A FRACTIONAL STEP NAVIER-STOKES ALGORITHM
K. GIANNAKOGLOU, G. SIMANDIRAKIS, and K. D. PAPAILIOU (Athens, National Technical University, Greece) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. refs
(ASME PAPER 91-GT-55)

An explicit, finite-difference, fractional-step Navier-Stokes method is presented for the prediction of two-dimensional turbomachinery cascade flows. The method also accounts for three-dimensional effects due to radius and streamtube thickness variations. The two-layer Baldwin-Lomax algebraic turbulent model is used to effect closure and its practical implementation is discussed in detail. Three different flow problems are examined and compared with experimental and numerical results obtained elsewhere. These cases deal with transonic flows in the last stage of a steam turbine rotor and a low solidity turbine cascade, as well as the subsonic flow around an isolated RAE2822 profile. The latter case was used for comparing two different transition criteria, implemented in the present code. C-type computational grids are used which are quasi-orthogonal in the near wall region. Author

A92-15534
COMPUTATION OF FLOW PAST A TURBINE BLADE WITH AND WITHOUT TIP CLEARANCE
W. R. BRILEY, D. V. ROSCOE, H. J. GIBELING, R. C. BUGGELN, J. S. SABNIS (Scientific Research Associates, Inc., Glastonbury, CT), P. D. JOHNSON, and F. W. HUBER (Pratt and Whitney Group, West Palm Beach, FL) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 11 p. refs
(ASME PAPER 91-GT-56)

Three-dimensional solutions of the ensemble-averaged Navier-Stokes equations have been computed for a high-turning turbine rotor passage, both with and without tip clearance effects. The geometry is Pratt and Whitney's preliminary design for the Generic Gas Generator Turbine (GGGT), having an axial chord of 0.5 inch and turning angle of about 160 deg. The solutions match the design Reynolds number of 3 x 10 exp 6/in. and design inflow/outflow distributions of flow quantities. The grid contains 627,000 points, including 20 radial points in the clearance gap of 0.015 in., and has a minimum spacing of 10 exp -4 in. adjacent to all surfaces. The solutions account for relative motion of the blade and shroud surfaces and include a backstep on the shroud. Computed results are presented which show the general flow behavior, especially near the tip clearance and backstep regions. The results are generally consistent with experimental observations for other geometries having thinner blades and smaller turning angles. Author

A92-15535
TURBULENCE MODELLING FOR SECONDARY FLOW PREDICTION IN A TURBINE CASCADE
J. G. E. CLEAK and D. G. GREGORY-SMITH (Durham, University, England) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 11 p. Research supported by SERC and Rolls-Royce, PLC. refs
(ASME PAPER 91-GT-57)

Predictions of secondary flow in an axial turbine cascade have been made using three different turbulence models; mixing length, a one equation model and a k-epsilon/mixing length hybrid model. The results are compared with results from detailed measurements, not only by looking at mean flow velocities and total pressure loss, but also by assessing how well turbulence quantities are predicted. It is found that the turbulence model can have a big influence on the mean flow results, with the mixing length model giving generally the best mean flow. None of the models give good predictions of the turbulent shear stresses in the vortex region, although the k-epsilon model gives quite good turbulent kinetic energy values. The one equation model is the only one to contain a transition criterion. The importance of such a criterion is illustrated, but the present one needs development to give reliable predictions in the complex flow within a blade passage. Author

A92-15536
3-D LOSS PREDICTION BASED ON SECONDARY FLOW AND BLADE SHEAR LAYER INTERACTION
D. T. KATRAMATOS (In2Tec, Ltd., Research and Development Dept., Athens, Greece) and J. K. KALDELLIS (Piraeus, University; In2Tec, Ltd., Research and Development Dept., Athens, Greece) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 12 p. refs
(ASME PAPER 91-GT-59)

The 3D loss distribution along axial turbomachines has been investigated. For this purpose, a well documented secondary flow calculation method has been interactively coupled with fast blade-to-blade shear layer calculation code, in order to predict the complete secondary flow and profile loss distribution. The blade-to-blade code predicts the profile loss distribution and subsequently provides the correct total pressure field for the secondary flow calculation. The combination of the above-mentioned codes gives a realistic picture of the flow quantities at any S3 surface along a machine at a minimal computer cost. Several test cases, including axial compressor and turbine cascades as well as transonic axial compressor blade rows, have been investigated. The results are in good agreement with the experimental data and are favorably compared with various recent correlations. Author

A92-15539* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A VISCOUS FLOW STUDY OF SHOCK-BOUNDARY LAYER INTERACTION, RADIAL TRANSPORT, AND WAKE DEVELOPMENT IN A TRANSONIC COMPRESSOR
CHUNILL HAH and LONNIE REID (NASA, Lewis Research Center, Cleveland, OH) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 14 p. refs
(ASME PAPER 91-GT-69)

A numerical study based on the 3D Reynolds-averaged Navier-Stokes equation has been conducted to investigate the detailed flow physics inside a transonic compressor. 3D shock structure, shock-boundary layer interaction, flow separation, radial mixing, and wake development are all investigated at design and off-design conditions. Experimental data based on laser anemometer measurements are used to assess the overall quality of the numerical solution. An additional experimental study to investigate end-wall flow with a hot-film was conducted, and these results are compared with the numerical results. Detailed

comparison with experimental data indicates that the overall features of the 3D shock structure, the shock-boundary layer interaction, and the wake development are all calculated very well in the numerical solution. The numerical results are further analyzed to examine the radial mixing phenomena in the transonic compressor. A thin sheet of particles is injected in the numerical solution upstream of the compressor. The movement of particles is traced with a 3D plotting package. This numerical survey of tracer concentration reveals the fundamental mechanisms of radial transport in this transonic compressor. Author

A92-15545
AN IMPROVED METHOD FOR AERODYNAMIC DESIGN OF CENTRIFUGAL IMPELLER BLADES
ZHENGMING WANG, BANGXIAN WU, and WU ZHANG (Chinese Academy of Sciences, Institute of Engineering Thermophysics, Beijing, People's Republic of China) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. Research supported by K.C. Wong Education Foundation. refs
(ASME PAPER 91-GT-76)

Based on the general theory of three-dimensional flow in turbomachines, an improved method for designing centrifugal impeller blades has been developed. The design procedure is performed with the help of the combination of an S2 inverse problem code, a code for generating a profile on a revolution surface by a two-step series expansion and the codes of S1 direct and inverse problems. After the calculation of the inverse problem on the S2 stream surface is completed, a special series expansion method is used for obtaining a preliminary blade profile, then the relative flowfield is predicted by the Si direct code and is improved by the Si inverse code. The method is favorable for smoothing the velocity distribution on the blade surface, eliminating the separation bubble and raising the efficiency of the impeller. The present method has been successfully applied to improving the design of a centrifugal impeller. Author

A92-15547
COMPUTATION OF 3D FLOW PHENOMENA IN AXIAL FLOW COMPRESSOR BLADE ROWS
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(ASME PAPER 91-GT-78)

Results obtained with a 3D partially parabolic calculation procedure are compared with experimental data for 3D flow in stationary and rotating blade rows of axial flow compressors. For the three blade rows considered here, the agreement between the calculations and the experimental results is good. In particular, calculations for the flow field within the rotor blade passage demonstrate that the 3D pressure correction equation models upstream flow effects in a satisfactory manner. V.L.

A92-15548
A 3D FEM VARIATIONAL AERODYNAMIC CALCULATION AND PERFORMANCE ANALYSIS OF A LEANED TURBINE STATOR CASCADE
ZHI-GANG ZHANG, DONG-MEI ZHOU, and YAN-SHENG LI (Shanghai Institute of Mechanical Engineering, People's Republic of China) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 4 p. refs
(ASME PAPER 91-GT-79)

An investigation into the pressure distribution in a turbine nozzle cascade with and without leaned blades has been made using a 3D subsonic variational FEM. It is concluded that the gas flow circulation is the essential factor of redistributing the secondary flow loss along the blade height in a leaned cascade. In addition, this paper recommends a direction for further research into the leaned stator cascade. Author

A92-15549
QUASI-THREE-DIMENSIONAL CHARACTERISTICS METHOD FOR A SUPERSONIC COMPRESSOR ROTOR
A. BOELCS and V. TSAMOURTZIS (Lausanne, Ecole Polytechnique Federale, Switzerland) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 13 p. refs
(ASME PAPER 91-GT-81)

A new quasi-3D characteristics method has been developed to calculate the supersonic flow in a compressor rotor on an axisymmetric stream surface with variable radius and stream tube thickness. The method is valid for supersonic inlet flow with an attached shock wave at the blade leading edge where the inlet Mach number and flow angle are related by the unique incidence condition. On the basis of the quasi-3D characteristics method, a simple quasi-3D method has also been derived that calculates the unique incidence condition and the Mach number distribution on the suction side of the profile for a given stream surface and stream tube thickness. The reliability of the simple method is established by comparing results with those obtained by Denton's time-marching method as well as those from the quasi-3D characteristics method. Systematic calculations performed using the simple quasi-3D method show the effects of varying the geometrical parameters of the cascade for different stream tube thickness and stream surface radius evolutions through the rotor. Author

A92-15550* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THE ROLE OF TIP CLEARANCE IN HIGH-SPEED FAN STALL
J. J. ADAMCZYK (NASA, Lewis Research Center, Cleveland, OH), M. L. CELESTINA (NASA, Lewis Research Center; Sverdrup Technology, Inc., Cleveland, OH), and E. M. GREITZER (MIT, Cambridge, MA) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 14 p. refs
(Contract NSG-3208)
(ASME PAPER 91-GT-83)

A numerical experiment has been carried out to define the near-stall casing endwall flowfield of a high-speed fan rotor. The experiment used a simulation code incorporating a simple clearance model, whose calibration is presented. The results of the simulation show that the interaction of the tip leakage vortex and the in-pasage shock plays a major role in determining the fan flow range. More specifically, the computations imply that it is the area increase of this vortex as it passes through the in-passage shock, which is the source of the blockage associated with stall. In addition, for fans of this type, it is the clearance over the forward portion of the fan blade which controls the flow processes leading to stall. Author

A92-15551
STALL INCEPTION IN AXIAL FLOW COMPRESSORS
I. J. DAY (Cambridge, University, England) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 9 p. Research supported by SERC. refs
(ASME PAPER 91-GT-86)

Studies have been conducted on two laboratory test compressors to investigate the process leading to the formation of finite amplitude rotating stall cells. The measurements were obtained from circumferential arrays of hot-wires and were spatially and temporarily analyzed to show that modal perturbations are not always present prior to stall, and when present, sometimes have little direct effect on the formation of the stall cells. The measurements lead to the conclusion that the occurrence of modal perturbations, and the formation of finite amplitude stall cells, are two separate phenomena; both occurring under roughly the same conditions at the peak of the pressure rise characteristic. The measurements also underline the hitherto unsuspected importance

of short length scale disturbances in the process of stall inception. Examples are given of different ways in which stall cells can develop and the conclusions are backed up with a summary of current test data from various machines around the world. Author

A92-15554
THREE-DIMENSIONAL FLOW AND MIXING IN A AXIAL FLOW COMPRESSOR WITH DIFFERENT ROTOR TIP CLEARANCES
AKIRA GOTO (Ebara Research Co., Ltd., Fujisawa, Japan) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 11 p. Research supported by Rolls-Royce, PLC and Ebara Corp. refs
(ASME PAPER 91-GT-89)

The effect of difference in rotor tip clearance on the mean flow fields and unsteadiness and mixing across a stator blade row were investigated using hot-wire anemometry, pressure probes, flow visualization and the ethylene tracer-gas technique on a single stage axial flow compressor. The structure of the three-dimensional flow fields was discussed based on results of experiments using the 12-orientation single slanted hot-wire technique and spectrum analysis of velocity fluctuation. High-pass filtered measurements of turbulence were also carried out in order to confirm small-scale velocity fluctuation which is more realistically referred to as turbulence. The spanwise distribution of ethylene gas spreading, estimated by the measured small-scale velocity fluctuation at the rotor exit, agreed quite well with that which was experimentally measured. This fact suggests the significant role of turbulence, generated within the rotor, in the mixing process across the downstream stator. The value of the maximum mixing coefficient in the tip region was found to increase linearly as the tip clearance became enlarged, starting from the value at midspan. Author

A92-15555
UNSTEADY VISCOUS FLOW IN A HIGH SPEED CORE COMPRESSOR
M. A. CHERRETT and J. D. BRYCE (Royal Aerospace Establishment, Propulsion Dept., Farnborough, England) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. Previously announced in STAR as N91-30480. refs
(ASME PAPER 91-GT-91)

A probe incorporating a miniature high-frequency response pressure transducer traversed behind the first three stages of a high-speed multistage compressor operating at throttle settings corresponding to near choke, peak efficiency and near surge, is described. A novel method of compensating for transducer temperature sensitivity was employed. Consequently, time-averaged pressures derived from the transducer were found to be in good agreement with pneumatic pressure measurements. Analysis of the unsteady measurements revealed both the periodic and random fluctuations in the flow field. This provided information on rotor-rotor interaction effects and the nature of viscous blade wake and secondary flows in each stage. Author

A92-15556
AN INVESTIGATION OF A STRONG SHOCK-WAVE TURBULENT BOUNDARY LAYER INTERACTION IN A SUPERSONIC COMPRESSOR CASCADE
H. A. SCHREIBER and H. STARKEN (DLR, Institut fuer Antriebstechnik, Cologne, Federal Republic of Germany) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 11 p. refs
(ASME PAPER 91-GT-92)

Experiments have been performed in a supersonic cascade facility to elucidate the fluid dynamic phenomena and loss mechanism of a strong shock-wave turbulent boundary layer interaction in a compressor cascade. The cascade geometry is typical for a transonic fan tip section that operates with a relative inlet Mach number of 1.5, a flow turning of about 3 deg, and a static pressure ratio of 2.15. The strong oblique and partly normal blade passage shock-wave with a pre-shock Mach number level of 1.42 to 1.52 induces a turbulent boundary layer separation on the blade suction surface. Freestream Reynolds number based on chord length was about 2.7 x 10 exp 6. Cascade overall performance, blade surface pressure distributions, schlieren photographs, and surface visualizations are presented. Detailed Mach number and flow direction profiles of the interaction region and the corresponding boundary layer have been determined using a laser-2-focus anemometer. The obtained results indicated that the axial blade passage stream sheet contraction (axial velocity density ratio) has a significant influence on the mechanism of strong interaction and the resulting total pressure losses. Author

A92-15557
EFFECTS OF STATOR WAKES AND SPANWISE NONUNIFORM INLET CONDITIONS ON THE ROTOR FLOW OF AN AXIAL TURBINE STAGE
J. ZESCHKY and H. E. GALLUS (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 11 p. refs
(ASME PAPER 91-GT-93)

Detailed measurements have been performed in a subsonic axial-flow turbine stage to investigate the structure of the secondary flowfield and the loss generation. The data include the static pressure distribution on the rotor blade passage surfaces and radial-circumferential measurements of the rotor exit flowfield using 3D hot-wire and pneumatic probes. The flowfield at the rotor outlet is derived from unsteady hot-wire measurements with high temporal and spatial resolution. The formation of the tip clearance vortex and the passage vortices is presented, which are strongly influenced by the spanwise nonuniform stator outlet flow. Taking the experimental values for the unsteady flow velocities and turbulence properties, the effect of the periodic stator wakes on the rotor flow is discussed. Author

A92-15565
THREE DIMENSIONAL FLOW IN A LINEAR COMPRESSOR CASCADE AT DESIGN CONDITIONS
CH. HIRSCH (Brussel, Vrije Universiteit, Brussels, Belgium) and SHUN KANG (Harbin Institute of Technology, People's Republic of China) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. refs
(ASME PAPER 91-GT-114)

Experimental data measured upstream, inside and downstream of a large-scale linear compressor cascade with NACA 65-1810 blade profile are presented. The flow is surveyed at 15 traverse planes with 14(in half span) x 24(in pitch) points inside a passage, and 14 x 33 points downstream exit plane. The measurements are obtained with a small size five-hole probe, and wall static pressure taps. It is observed that the three-dimensional flow inside and behind the cascade is characterized, not only by the conventional aspects, such as leading edge horseshoe vortices, passage vortices, trailing edge vortex sheet and corner vortices, but also by two spiral node points, formed from the three-dimensional separation lines, on suction surface, and the resulting concentrated vortices. Author

A92-15568
SIMILARITY TRANSFORMATIONS FOR COMPRESSOR BLADING
N. G. ZHU, L. XU, and M. Z. CHEN (Beijing University of Aeronautics and Astronautics, People's Republic of China) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. refs
(ASME PAPER 91-GT-123)

Improving the performance of high-speed axial compressors through low-speed model compressor testing has proved to be economical and effective (Wisler, 1984). The key to this technique is to design low-speed blade profiles which are aerodynamically similar to their high-speed counterparts. The conventional aerodynamic similarity transformation involves the small disturbance potential flow assumption, therefore its application is severely limited and generally not used in practical design. In this paper, a set of higher-order transformation rules are presented which can

accommodate large disturbances at transonic speed and are therefore applicable to similar transformations between the high-speed HP compressor and its low-speed model. Local linearization is used in the nonlinear equations and the transformation is obtained in an iterative process. The transformation gives the global blading parameters such as camber, incidence and solidity as well as the blade profile. Both numerical and experimental validations of the transformation show that the nonlinear similarity transformations do retain satisfactory accuracy for highly loaded blades up to low transonic speeds. Further improvement can be made by only slightly modifying profiles numerically without altering the global similarity parameters.
Author

A92-15569
THE SIMULATION OF THREE-DIMENSIONAL VISCOUS FLOW IN TURBOMACHINERY GEOMETRIES USING A SOLUTION-ADAPTIVE UNSTRUCTURED MESH METHODOLOGY
W. N. DAWES (Cambridge, University, England) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 11 p. refs
(ASME PAPER 91-GT-124)

This paper presents a numerical method for the simulation of flow in turbomachinery blade rows using a solution-adaptive mesh methodology. The fully three-dimensional, compressible, Reynolds averaged Navier-Stokes equations with k-epsilon turbulence modeling (and low Reynolds number damping terms) are solved on an unstructured mesh formed from tetrahedral finite volumes. At stages in the solution, mesh refinement is carried out based on flagging cell faces with either a fractional variation of a chosen variable (like Mach number) greater than a given threshold or with a mean value of the chosen variable within a given range. Several solutions are presented, including that for the highly three-dimensional flow associated with the corner stall and secondary flow in a transonic compressor cascade, to demonstrate the potential of the new method. Author

A92-15571
INVISCID-VISCOUS COUPLED SOLUTION FOR UNSTEADY FLOWS THROUGH VIBRATING BLADES. II - COMPUTATIONAL RESULTS
L. HE and J. D. DENTON (Cambridge, University, England) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 9 p. Research sponsored by Rolls-Royce, PLC. refs
(ASME PAPER 91-GT-126)

A quasi-3D inviscid-viscous coupled approach has been developed for unsteady flows around oscillating blades, as described in Part 1. To validate this method, calculations for several steady and unsteady flow cases with strong inviscid-viscous interactions are performed, and the results are compared with the corresponding experiments. Calculated results for unsteady flows around a bi-convex cascade and a fan tip section highlight the necessity of including viscous effects in predictions of turbomachinery blade flutter at transonic flow conditions. Author

A92-15572
EFFECTS OF SIMULATED ROTATION ON TIP LEAKAGE IN A PLANAR CASCADE OF TURBINE BLADES. I - TIP GAP FLOW
M. I. YARAS and S. A. SJOLANDER (Carleton University, Ottawa, Canada) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 10 p. Research supported by Pratt and Whitney Canada. refs
(Contract NSERC-A-1671)
(ASME PAPER 91-GT-127)

The paper presents further results from a continuing study on tip leakage in axial turbines. Rotation has been simulated in a linear cascade test section by using a moving-belt tip wall. Measurements were made inside the tip gap with a three-hole pressure probe for a clearance size of 3.8 percent of the blade chord. Two wall speeds are considered and the results are compared with the case of no rotation. As in other experiments, significant reduction in the gap mass flow rate is observed due to the relative motion. The detailed nature of the measurements allows the dominant physical mechanism by which wall motion affects the tip gap flow to be identified. Based on the experimental observations, an earlier model for predicting the tip gap flowfield is extended to the case of relative wall motion. The effect of the relative motion on the downstream flowfield and the blade loading is examined. Author

A92-15573
EFFECTS OF SIMULATED ROTATION ON TIP LEAKAGE IN A PLANAR CASCADE OF TURBINE BLADES. II - DOWNSTREAM FLOW FIELD AND BLADE LOADING
M. I. YARAS, S. A. SJOLANDER, and R. J. KIND (Carleton University, Ottawa, Canada) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 10 p. Research supported by Pratt and Whitney Canada. refs
(Contract NSERC-A-1671)
(ASME PAPER 91-GT-128)

Experimental results are presented on the effects of simulated rotation on the tip leakage in a linear turbine-cascade test. The downstream flow field is examined. For clearances sizes of 2.4 and 3.8 percent of the blade chord measurements were made in two planes downstream of the trailing edge using a seven-hole pressure probe. Significant changes in the tip-leakage vortex and passage-vortex structures are observed with the introduction of relative motion. The effects of clearance size and rotation on the relationship between bound circulation and tip-vortex circulation are discussed. The validity of a previously developed tip-vortex model for the case of rotation is examined in the light of the measurements. For clearance of 1.5, 2.4 and 3.8 percent of the blade chord the effects of rotation on blade loading are studied through static pressure measurements on the blade surfaces. The distortion of the surface pressure field near the tip is found to be reduced with increasing wall speed. This is consistent with the reduced strength of the tip-leakage vortex as wall speed is increased. For all measurements two wall speeds are considered and the results are compared with the case of no rotation.
Author

A92-15574* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THE EFFECT OF STEADY AERODYNAMIC LOADING ON THE FLUTTER STABILITY OF TURBOMACHINERY BLADING
TODD E. SMITH (NASA, Lewis Research Center, Cleveland; Sverdrup Technology, Inc., Brook Park, OH) and JAIKRISHNAN R. KADAMBI (Case Western Reserve University, Cleveland, OH) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 9 p. Previously announced in STAR as N91-19479. refs
(Contract NAS3-25266)
(ASME PAPER 91-GT-130)

An aeroelastic analysis is presented which accounts for the effect of steady aerodynamic loading on the aeroelastic stability of a cascade of compressor blades. The aeroelastic model is a two degree of freedom model having bending and torsional displacements. A linearized unsteady potential flow theory is used to determine the unsteady aerodynamic response coefficients for the aeroelastic analysis. The steady aerodynamic loading was caused by the addition of airfoil thickness and camber and steady flow incidence. The importance of steady loading on the airfoil unsteady pressure distribution is demonstrated. Additionally, the effect of steady loading on the tuned flutter behavior and flutter boundaries indicates that neglecting either airfoil thickness, camber or incidence could result in nonconservative estimates of flutter behavior. Author

A92-15575
AN UNSTEADY LIFTING SURFACE THEORY FOR DUCTED FAN BLADES
RAY M. CHI (United Technologies Research Center, East Hartford, CT) ASME, International Gas Turbine and Aeroengine Congress

and Exposition, 36th, Orlando, FL, June 3-6, 1991. 17 p. Research sponsored by United Technologies Corp. refs
(ASME PAPER 91-GT-131)

A frequency domain lifting surface theory is developed to predict the unsteady aerodynamic pressure loads on oscillating blades of a ducted subsonic fan. The steady baseline flow as observed in the rotating frame of reference is the helical flow dictated by the forward flight speed and the rotational speed of the fan. The unsteady perturbation flow, which is assumed to be potential, is determined by solving an integral equation that relates the unknown jump in perturbation velocity potential across the lifting surface to the upwash velocity distribution prescribed by the vibratory motion of the blade. Examples of unsteady pressure distributions are given to illustrate the differences between the three dimensional lifting surface analysis and the classical two dimensional strip analysis. The effects of blade axial bending, bowing (i.e., circumferential bending) and sweeping on the unsteady pressure load are also discussed. Author

A92-15576* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
WIND TUNNEL WALL EFFECTS IN A LINEAR OSCILLATING CASCADE
D. H. BUFFUM (NASA, Lewis Research Center, Cleveland, OH) and S. FLEETER (Purdue University, West Lafayette, IN) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 12 p. Previously announced in STAR as N91-19098. refs
(ASME PAPER 91-GT-133)

Experiments in a linear oscillating cascade reveal that the wind tunnel walls enclosing the airfoils have, in some cases, a detrimental effect on the oscillating cascade aerodynamics. In a subsonic flowfield, biconvex airfoils are driven simultaneously in harmonic, torsion-mode oscillations for a range of interblade phase angle values. It is found that the cascade dynamic periodicity - the airfoil to airfoil variation in unsteady surface pressure - is good for some values of interblade phase angle but poor for others. Correlation of the unsteady pressure data with oscillating flat plate cascade predictions is generally good for conditions where the periodicity is good and poor where the periodicity is poor. Calculations based upon linearized unsteady aerodynamic theory indicate that pressure waves reflected from the wind tunnel walls are responsible for the cases where there is poor periodicity and poor correlation with the predictions. Author

A92-15577
THE EFFECT OF BLADE TIP GEOMETRY ON THE TIP LEAKAGE FLOW IN AXIAL TURBINE CASCADES
F. J. G. HEYES, H. P. HODSON (Cambridge, University, England), and G. M. DAILEY (Rolls-Royce, PLC, Derby, England) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 9 p. refs
(ASME PAPER 91-GT-135)

The phenomenon of tip leakage has been studied in two linear cascades of turbine blades. The investigation includes an examination of the performance of the cascades with a variety of tip geometries. The effects of using plain tips, suction side squealers and pressure side squealers are reported. Traverses of the exit flowfield were made in order to determine the overall performance. A method of calculating the tip discharge coefficients for squealer geometries is put forward. In linking the tip discharge coefficient and cascade losses a procedure for predicting the relative performance of tip geometries is developed. The model is used to examine the results obtained using the different tip treatments and to highlight the important aspects of the loss generation process. Author

A92-15580* Army Aviation Systems Command, Cleveland, OH.
NASA LOW-SPEED CENTRIFUGAL COMPRESSOR FOR 3-D VISCOUS CODE ASSESSMENT AND FUNDAMENTAL FLOW PHYSICS RESEARCH
M. D. HATHAWAY (U.S. Army, Propulsion Directorate, Cleveland, OH), J. R. WOOD (NASA, Lewis Research Center, Cleveland, OH), and C. A. WASSERBAUER (NASA, Lewis Research Center; Sverdrup Technology, Inc., Cleveland, OH) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 13 p. Previously announced in STAR as N91-20044. refs
(ASME PAPER 91-GT-140)

A low speed centrifugal compressor facility recently built by the NASA Lewis Research Center is described. The purpose of this facility is to obtain detailed flow field measurements for computational fluid dynamic code assessment and flow physics modeling in support of Army and NASA efforts to advance small gas turbine engine technology. The facility is heavily instrumented with pressure and temperature probes, both in the stationary and rotating frames of reference, and has provisions for flow visualization and laser velocimetry. The facility will accommodate rotational speeds to 2400 rpm and is rated at pressures to 1.25 atm. The initial compressor stage being tested is geometrically and dynamically representative of modern high-performance centrifugal compressor stages with the exception of Mach number levels. Preliminary experimental investigations of inlet and exit flow uniformly and measurement repeatability are presented. These results demonstrate the high quality of the data which may be expected from this facility. The significance of synergism between computational fluid dynamic analysis and experimentation throughout the development of the low speed centrifugal compressor facility is demonstrated. Author

A92-15583
A NUMERICAL PROCEDURE OF THREE-DIMENSIONAL DESIGN PROBLEM IN TURBOMACHINERY
J. Z. XU and C. W. GU (Chinese Academy of Sciences, Institute of Engineering Thermophysics, Beijing, People's Republic of China) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 5 p. Research supported by NNSFC. refs
(ASME PAPER 91-GT-144)

A numerical method for solving the three-dimensional aerothermodynamic design problem with some type of the Mach number distributions on the blade surfaces is presented. In the usual aerothermodynamic design of a turbomachinery the three-dimensional coordinates of the blade is attained through the stacking of the cascade profiles and may not ensure the desired velocity distribution. To avoid this problem the present method will give new coordinates of the blade according to the required Mach number distribution. The method is based on the pseudostream function formulation and the treatment of the boundary conditions in the design problem is given. The numerical results show that the method is simple and useful in design. Author

A92-15584
THREE-DIMENSIONAL NAVIER-STOKES COMPUTATION OF TURBOMACHINERY FLOWS USING AN EXPLICIT NUMERICAL PROCEDURE AND A COUPLED K-EPSILON TURBULENCE MODEL
R. F. KUNZ and B. LAKSHMINARAYANA (Pennsylvania State University, University Park) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 21 p. refs
(Contract DAAL03-86-G-0044)
(ASME PAPER 91-GT-146)

An explicit, three-dimensional, coupled Navier-Stokes/k-epsilon technique has been developed and successfully applied to complex internal flow calculations. Several features of the procedure, which enable convergent and accurate calculation of high Reynolds number 2D cascade flows have been extended to three dimensions, including a low Reynolds number compressible form of the k-epsilon turbulence model, local time-step specification based on hyperbolic and parabolic stability requirements, and eigenvalue and local velocity scaling of artificial dissipation operators. A flux evaluation procedure which eliminates the finite difference metric singularity, at leading and trailing edges, on H- and C-grids, is presented. The code is used to predict the pressure distribution, primary

velocity and secondary flows in an incompressible, turbulent curved duct flow for which CFD validation quality data is available. Also, a subsonic compressor rotor passage, for which detailed laser, rotating hot-wire, and five-hole pressure probe measurements have been made, is computed. Author

A92-15586
MULTI-BLADE ROW NAVIER-STOKES SIMULATIONS OF FAN-BYPASS CONFIGURATIONS
W. N. DAWES (Cambridge, University, England) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 7 p. refs
(ASME PAPER 91-GT-148)

This paper describes extensions to a multi-blade row 3D Navier-Stokes solver to enable fan-splitter-bypass geometries to be handled. The code is applied to two generic configurations. The core-bypass splitter can exert considerable upstream influence via its associated pressure field and in the example shown here severely disturbs the fan suction surface boundary layer. The behavior of the bypass ogv is substantially modified both by the clearance flow of the upstream fan and also by thicker than expected boundary layers on the splitter upper surface caused by the splitter LE incidence associated with the particular bypass ratio selected for the example. Author

A92-15603
UNSTEADY EULER CALCULATIONS IN 2-D INTERNAL AERODYNAMICS WITH INTRODUCED VORTICITY
M. HADZIDAKIS, F. KARAGIANNIS, P. CHAVIAROPOULOS, and K. D. PAPAILIOU (Athens, National Technical University, Greece) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 12 p. Research supported by Dassault Aviation. refs
(ASME PAPER 91-GT-168)

This paper presents an implicit finite difference algorithm which solves the unsteady Euler equations in two-dimensional ducts. The unsteady nature of the flow is due to the time dependent inflow and outflow boundary conditions, while the geometry does not change in time. The present work is based on the Helmholtz decomposition of the unsteady velocity field into a potential and a rotational part. Vorticity is introduced at the inlet by means of velocity, total enthalpy or even entropy slope. The presented results cover a wide range of reduced frequencies in the subsonic regime. Author

A92-15606
A CALCULATION PROCEDURE FOR THREE-DIMENSIONAL TURBULENT FLOW IN A CENTRIFUGAL IMPELLER WITH ANY BLADE GEOMETRY
GUANG XI, SHANGJIN WANG, and YONGMIAO MIAO (Xian Jiaotong University, People's Republic of China) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 6 p. refs
(ASME PAPER 91-GT-171)

A method for calculating 3D turbulent flow in a centrifugal impeller is developed by solving the incompressible, steady, time-averaged N-S equation in general curvilinear coordinates. The K-epsilon two-equation turbulence model is utilized to describe Reynolds stresses. A calculation scheme is proposed which divides a centrifugal compressor impeller into three calculation zones: the inlet zone, the channel zone, and the exit-vaneless diffuser zone. A simple and time-saving method for generating 3D body-fitted coordinate system of a centrifugal impeller is established by means of combining an algebraic transformation with the solution of 2D elliptic partial differential equations. This method is applied to calculate the turbulent flow in an industrial centrifugal compressor impeller. The tendency of the 'jet-wake' formation and growth in the impeller can be seen. The calculation results at the impeller exit are in agreement with the experimental results. Author

A92-15608
THE INFLUENCE OF SHOCK WAVES ON THE VISCOUS FLOW FIELD OF AXIAL COMPRESSORS
J. K. KALDELLIS, D. T. KATRAMATOS (Piraeus, University, Greece), and P. D. KTENIDIS (Athens, National Technical University, Greece) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 9 p. refs
(ASME PAPER 91-GT-173)

Changes in flowfield due to the presence of shock waves in axial compressors are examined with a simple but realistic model used to predict the static pressure, the relative Mach number, the total pressure and the total temperature distributions through the shock region. These distributions are strongly affected by the interaction between the shock waves and the shear layers or the secondary flowfield. The secondary flow code along with a fast compressible shear-layer-calculation method are utilized in order to provide the necessary quantities of viscous flow for the approximate shock-viscous flow-interaction procedure. The shock-induced losses, along with the increased shear-layer or secondary-flow losses, are also predicted. The complete procedure is applied to several test cases and the results of the proposed method are compared with results of previous calculations and the available experimental data. Finally, the flowfield through the rotor of a supersonic compressor is thoroughly analyzed, and major conclusions concerning the modification of the secondary flowfield due to the shock wave appearance are given. Author

A92-15610
UNSTEADY LIFTING SURFACE THEORY FOR A ROTATING TRANSONIC CASCADE OF SWEPT BLADES
HIDEKAZU KODAMA (Ishikawajima-Harima Heavy Industries, Tokyo, Japan) and MASANOBU NAMBA (Kyushu University, Fukuoka, Japan) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 12 p. refs
(ASME PAPER 91-GT-178)

A lifting surface theory is developed to predict the unsteady three-dimensional aerodynamic characteristics for a rotating transonic annular cascade of swept blades. An improved method is used to solve the integral equation for the unsteady blade loading. Numerical examples are presented to demonstrate effects of the sweep on the blade flutter and on the acoustic field generated by interaction of rotating blades with a convected sinusoidal gust. It is found that, in the case of transonic rotors, the magnitude of total aerodynamic work due to the blade vibration is reduced at large sweep angles, however blade sweep is not beneficial for noise reduction. Author

A92-15613
AN EXPERIMENT ON UNSTEADY FLOW OVER AN OSCILLATING AIRFOIL
L. HE and J. D. DENTON (Cambridge, University, England) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. Research supported by Rolls-Royce, PLC. refs
(ASME PAPER 91-GT-181)

In order to enhance understanding of viscous-dominated blade flutter and to provide experimental data for validating unsteady viscous-flow solutions, unsteady flow over a 2D NACA-65 airfoil oscillating in torsion at an amplitude of 2 deg and a reduced frequency up to 0.69 is experimentally investigated in a low-speed wind tunnel under different loading conditions. Unsteady pressure distribution is measured on both suction and pressure surfaces using pressure transducers. On the suction surface hot-film measurements are conducted to indicate the development of the unsteady boundary layer. Unsteady boundary-layer behavior and its effects on the airfoil's aeroelasticity at the different loading conditions are demonstrated. The results also throw some light on understanding the onset mechanism of 'dynamic stall' which involves a persistent convective pressure-wave pattern with marked unstable aeroelastic characteristics. Author

A92-15615
ANALYSIS AND PREDICTION OF TRANSONIC TURBINE BLADE LOSSES

C. L. S. FARN, D. K. WHIRLOW (Westinghouse Science and Technology Center, Pittsburgh, PA), and S. CHEN (Westinghouse Electric Corp., Technology Strategic Operations Div., Orlando, FL) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 7 p. refs
(ASME PAPER 91-GT-183)

A computationally efficient method for predicting blade losses in the transonic regime with an accuracy sufficient for design purposes is presented. The method uses a combination of standard inviscid and boundary layer techniques with an analytical treatment of downstream mixing and empirical shock models. The relative importance of three loss mechanisms in different Mach number regions of the transonic blade flow is identified. Downstream mixing loss is found to be dominant at higher Mach numbers but the value can be lowered by use of converging-diverging blade passages. Shock wave losses is found to be most important in the intermediate Mach number region around unity and to diminish away from that region. Boundary layer losses vary little with Mach number at values typical of transonic design but do vary with blade type, being the dominant loss form for hub sections. C.D.

A92-15616* General Motors Corp., Indianapolis, IN.
TIME-DEPENDENT AERODYNAMIC ANALYSIS OF DUCTED AND UNDUCTED PROPFANS AT ANGLE OF ATTACK
EDWARD J. HALL and ROBERT A. DELANEY (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 14 p. refs
(Contract NAS3-25270)
(ASME PAPER 91-GT-190)

A three-dimensional unsteady aerodynamic analysis is described for predicting the time-dependent flow about ducted and unducted propfans operating at angle of attack. Although the freestream is assumed to be uniform, the flow relative to the rotating blades varies with circumferential position, resulting in an inherent unsteadiness due to the nonaxial inflow. The time-dependent Euler equations are solved utilizing a Runge-Kutta time-stepping scheme. The analysis is based on a finite-volume discretization employing a multiple-block grid network. To permit the use of large calculation time steps, an implicit residual smoothing scheme previously tested for unsteady flow calculations in two dimensions is extended to three spatial dimensions. For unducted propfans, a single H-type grid block is used for each blade passage to determine the time-periodic flowfield. For ducted propfans (ultra-high bypass fans) a body-centered C-type grid is wrapped about the cowl to improve the accuracy of the analysis in the high gradient flow region near the cowl leading edge. Numerical results are compared with available data for both ducted and unducted propfans operating at angle of attack. Author

A92-15623* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EULER FLOW PREDICTIONS FOR AN OSCILLATING CASCADE USING A HIGH RESOLUTION WAVE-SPLIT SCHEME
DENNIS L. HUFF (NASA, Lewis Research Center, Cleveland, OH), TIMOTHY W. SWAFFORD (Mississippi State University, Mississippi State), and T. S. R. REDDY (Toledo, University, OH) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. Previously announced in STAR as N91-24107. refs
(ASME PAPER 91-GT-198)

A compressible flow code that can predict the nonlinear unsteady aerodynamic associated with transonic flows over oscillating cascades is developed and validated. The code solves the two dimensional, unsteady Euler equations using a time-marching, flux-difference splitting scheme. The unsteady pressures and forces can be determined for arbitrary input motions, although only harmonic pitching and plunging motions are addressed. The code solves the flow equations on a H-grid which is allowed to deform with the airfoil motion. Predictions are presented for both flat plate cascades and loaded airfoil cascades. Results are compared to flat plate theory and experimental data. Predictions are also presented for several oscillating cascades with strong normal shocks where the pitching amplitudes, cascade geometry and interblade phase angles are varied to investigate nonlinear behavior. Author

A92-15637
UNSTEADY NAVIER-STOKES SIMULATION OF TRANSONIC CASCADE FLOW USING AN UNFACTORED IMPLICIT UPWIND RELAXATION SCHEME WITH INNER ITERATIONS
M. FURUKAWA, T. NAKANO, and M. INOUE (Kyushu University, Fukuoka, Japan) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. refs
(ASME PAPER 91-GT-223)

An implicit upwind scheme is developed for Navier-Stokes simulations of unsteady flows in transonic cascades. The two-dimensional, Reynolds-averaged Navier-Stokes equations are discretized in space using a cell-centered finite-volume formulation and in time using the Euler implicit method. The inviscid fluxes are evaluated using a highly accurate upwind scheme based on a TVD formulation with the Roe's approximate Riemann solver, and the viscous fluxes are determined in a central differencing manner. The algebraic turbulence model of Baldwin and Lomax is employed. To simplify grid generations, a zonal approach with a composite zonal-grid system is implemented, in which periodic boundaries are treated as zonal boundaries. A time-linearization of the inviscid fluxes evaluated by the Roe's approximate Riemann solver is presented in detail. No approximate factorization is introduced, and unfactored equations are solved by a pointwise relaxation method. To obtain time-accurate solutions, 30 inner iterations are performed at each time step. Numerical examples are presented for unsteady flows in a transonic turbine cascade where periodic unsteadiness is caused by the trailing-edge vortex shedding. Author

A92-15638* Pennsylvania State Univ., University Park.
NUMERICAL PREDICTION OF WAKES IN CASCADES AND COMPRESSOR ROTORS INCLUDING THE EFFECTS OF MIXING. I - CASCADE WAKES INCLUDING THE EFFECTS OF INCIDENCE AND FREESTREAM TURBULENCE
B. LAKSHMINARAYANA (Pennsylvania State University, University Park) and N. SURYAVAMSHI ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 13 p. refs
(Contract NSG-3266)
(ASME PAPER 91-GT-225)

The results of a numerical investigation to predict the flow in the wake regions of compressor cascades, and wakes and mixing in rotors are presented. Attention is given to the flow in compressor cascades including the effects of change in loading (incidence) and the inlet freestream turbulence intensity. The numerical analysis shows a slight increase in the total pressure loss coefficient through the cascade with increasing turbulence levels. R.E.P.

A92-15639* Pennsylvania State Univ., University Park.
NUMERICAL PREDICTION OF WAKES IN CASCADES AND COMPRESSOR ROTORS INCLUDING THE EFFECTS OF MIXING. II - ROTOR PASSAGE FLOW AND WAKES INCLUDING THE EFFECTS OF SPANWISE MIXING
B. LAKSHMINARAYANA (Pennsylvania State University, University Park) and N. SURYAVAMSHI ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 13 p. refs
(Contract NSG-3266)
(ASME PAPER 91-GT-222)

The results of a numerical investigation to predict the flow field including wakes and mixing in axial-flow compressor rotors are presented. The wake behavior in a moderately loaded compressor rotor is studied numerically using a 3D incompressible Navier-Stokes solver with a high Reynolds number form of a turbulence model. The equations are solved using a time dependent implicit technique. The agreement between the measured data and the predictions is good; including the blade boundary-layer

profiles, wake mean-velocity profiles, and decay. The ability of the pseudocompressibility scheme to predict the entire flow field including the near and far wake profiles and its decay characteristics, effect of loading, and the viscous losses of a 3D rotor flow field are demonstrated. The mixing in the downstream regions away from the hub and annulus walls is dominated by wake diffusion. In regions away from the walls the radial mixing is predominantly caused by the transport of mass, momentum, and energy by the radial component of velocity in the wake. Author

A92-15646* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
INTERFERENCE EFFECTS OF VERY HIGH BYPASS RATIO NACELLE INSTALLATIONS ON A LOW-WING TRANSPORT
ANTHONY M. INGRALDI, RICHARD J. RE, ODIS C. PENDERGRAFT, JR. (NASA, Langley Research Center, Hampton, VA), and TIMMY T. KARIYA (Vigyan Research Associates, Inc., Hampton, VA) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. refs
(ASME PAPER 91-GT-241)

A twin-engine, low-wing transport model, with a supercritical wing designed for a cruise Mach number of 0.77 and a lift coefficient of 0.55 was tested in the 16-Foot Transonic Tunnel at NASA Langley Research Center. The purpose of this test was to compare the wing/nacelle interference effects of superfans (BPR 18) with the interference effects of advanced turbofans (BPR 6). Flow-through nacelles were used. Forces and moments on the complete model were measured using a strain gage balance, and extensive surface static pressure measurements were made on the model's wing, nacelles, and pylons. Results of the investigation indicate that superfan nacelles can be installed with approximately the same drag penalty as conventional turbofan nacelles. Author

A92-15662
PERFORMANCE IMPROVEMENTS OF COMPRESSOR CASCADES BY CONTROLLING THE PROFILE AND SIDEWALL BOUNDARY LAYERS
WOLFGANG STURM, HERMANN SCHEUGENPFLUG (Motoren- und Turbinen-Union Muenchen GmbH, Munich, Federal Republic of Germany), and LEONARD FOTTNER (Muenchen, Universitaet der Bundeswehr, Neubiberg, Federal Republic of Germany) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 12 p. Research supported by BMVg and Bundesamt fuer Wehrtechnik und Beschaffung. refs
(ASME PAPER 91-GT-260)

The objective of the study was to investigate how the performance of a highly loaded compressor cascade can be improved by using blowing to control the profile and corner boundary layers. In addition to pressurized air blowing, the use of slotted blades is also discussed due to the similarity of the mechanism of boundary layer control. Results of fundamental experiments in a cascade wind tunnel are reported, and recommendations are given concerning the application of blowing in compressor cascades. V.L.

A92-15669* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THE NUMERICAL SIMULATION OF A HIGH-SPEED AXIAL FLOW COMPRESSOR
RICHARD A. MULAC (NASA, Lewis Research Center; Sverdrup Technology, Inc., Cleveland, OH) and JOHN J. ADAMCZYK (NASA, Lewis Research Center, Cleveland, OH) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 14 p. refs
(ASME PAPER 91-GT-272)

The advancement of high-speed axial-flow multistage compressors is impeded by a lack of detailed flow-field information. Recent development in compressor flow modeling and numerical simulation have the potential to provide needed information in a timely manner. The development of a computer program is described to solve the viscous form of the average-passage equation system for multistage turbomachinery. Programming issues such as in-core versus out-of-core data storage and CPU utilization (parallelization, vectorization, and chaining) are addressed. Code performance is evaluated through the simulation of the first four stages of a five-stage, high-speed, axial-flow compressor. The second part addresses the flow physics which can be obtained from the numerical simulation. In particular, an examination of the endwall flow structure is made, and its impact on blockage distribution assessed. Author

A92-15670* Sverdrup Technology, Inc., Brook Park, OH.
DETERMINISTIC BLADE ROW INTERACTIONS IN A CENTRIFUGAL COMPRESSOR STAGE
K. R. KIRTLEY (Sverdrup Technology, Inc., Brook Park, OH) and T. A. BEACH (NASA, Lewis Research Center, Cleveland, OH) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 12 p. refs
(Contract NAS3-25266)
(ASME PAPER 91-GT-273)

The three-dimensional viscous flow in a low speed centrifugal compressor stage is simulated using an average passage Navier-Stokes analysis. The impeller discharge flow is of the jet/wake type with low momentum fluid in the shroud-pressure side corner coincident with the tip leakage vortex. This nonuniformity introduces periodic unsteadiness in the vane frame of reference. The effect of such deterministic unsteadiness on the time-mean is included in the analysis through the average passage stress, which allows the analysis of blade row interactions. The magnitude of the divergence of the deterministic unsteady stress is of the order of the divergence of the Reynolds stress over most of the span, from the impeller trailing edge to the vane throat. Although the potential effects on the blade trailing edge from the diffuser vane are small, strong secondary flows generated by the impeller degrade the performance of the diffuser vanes. Author

A92-15671
INLET FLOW ANGLE DETERMINATION OF TRANSONIC COMPRESSOR CASCADES
W. STEINERT, R. FUCHS, and H. STARKEN (DLR, Institut fuer Antriebstechnik, Cologne, Federal Republic of Germany) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. refs
(ASME PAPER 91-GT-274)

Tests of transonic compressor cascades require special measuring techniques to determine the inlet-flow angle around sonic inlet-flow conditions. One of the main requirements for these methods is the ability to adjust the inlet-flow angle during the test to a prescribed value. A method is successfully applied which relies on theoretically determined suction-surface velocities. The described method was applied in testing cascades at inlet Mach numbers between 0.75-1.18. The test results confirmed the practicability of this method. Author

A92-15689
TRANSONIC AND SUPERSONIC INVISCID COMPUTATIONS IN CASCADES USING ADAPTIVE UNSTRUCTURED MESHES
F. BASSI (Catania, Universita, Italy), S. REBAY (Milano, Politecnico, Milan, Italy), and M. SAVINI (CNR, CNPM, Peschiera Borromeo, Italy) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 10 p. refs
(ASME PAPER 91-GT-312)

The paper describes a solution procedure for two dimensional compressible inviscid flows. The solution algorithm uses a finite volume spatial discretization on unstructured grids of triangles and an explicit Runge-Kutta time marching scheme; for steady problems efficiency is enhanced by using local time stepping and enthalpy damping. The use of unstructured meshes automatically adapted to the solution allows arbitrary geometries and complicated flow features to be treated easily and with high degree of accuracy, even if more work is needed to reach a computational efficiency comparable to those of existing structured codes. Adaptation criteria based on error estimates of significant flow variables have been implemented and tested. The method has been applied to

the computation of transonic and supersonic flows in gas turbine nozzles and in impulse rotor cascades for spatial applications and the results have been compared with the experimental data.
Author

A92-15690* Florence Univ. (Italy).
TRANSONIC CASCADE FLOW PREDICTION USING THE NAVIER-STOKES EQUATIONS
A. ARNONE and S. S. STECCO (Firenze, Universita, Florence, Italy) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. Research supported by NASA and MPI. refs
(ASME PAPER 91-GT-313)

This paper presents results which summarize the work carried out during the last three years to improve the efficiency and accuracy of numerical predictions in turbomachinery flow calculations. A new kind of nonperiodic c-type grid is presented and a Runge-Kutta scheme with accelerating strategies is used as a flow solver. The code capability is presented by testing four *different blades at different exit Mach numbers in transonic regimes.* Comparison with experiments shows the very good reliability of the numerical prediction. In particular, the loss coefficient seems to be correctly predicted by using the well-known Baldwin-Lomax turbulence model. Author

A92-15703
NUMERICAL STUDY OF BRANCHED TURBOPROP INLET DUCTS USING A MULTIPLE BLOCK GRID PROCEDURE
ANIL K. TOLPADI and MARK E. BRAATEN (GE Research and Development Center, Schenectady, NY) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 7 p. Research sponsored by GE Aircraft Engines. refs
(ASME PAPER 91-GT-339)

It is demonstrated that the flow field in complex nonaxisymmetric branched turboprop inlet ducts can be successfully calculated using a multiple block grid viscous flow analysis code. A body-fitted grid for this complex geometry is generated and a coupled block grid solution for the flow is obtained. The calculated total pressure recovery factor, a quantity of interest to designers of such ducts, is found to agree well with measurements within the limits of the grid resolution. It is shown that with a refined grid the calculated value is in closer agreement with measurements. The code provides the distribution of the flow at the engine face, which is of great value to designers. The trajectory analysis provides information concerning the path of various debris entering the duct. C.D.

A92-15718
DESIGN AND PERFORMANCE OF ADVANCED BLADING FOR A HIGH-SPEED HP COMPRESSOR
R. B. GINDER (Royal Aerospace Establishment, Farnborough, England) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. Previously announced in STAR as N91-30146. refs
(ASME PAPER 91-GT-374) Copyright

A set of advanced blading was designed for a five stage high speed research cone compressor. The blade profiles were aerodynamically tailored using a sophisticated quasi three dimensional S1-S2 flow calculation system. This system involves iteration between blade to blade calculations using an inviscid viscous code, and a streamline curvature calculation for the pitchwise averaged throughflow. The design and measured performance of the new compressor are compared with an initial conventionally bladed four stage version. The new design achieved a peak level of polytropic efficiency approaching 91 percent, a substantial improvement on the initial version, but showed a shortfall in pressure ratio compared with design intent. Post test analyses based on measured performance data are used to give further insight into this result and indicate possible improvements in the design approach. Author

A92-15730
INLET PLANAR WAVES - A CURRENT PERSPECTIVE
W. H. BALL (Boeing Co., Military Airplanes Div., Seattle, WA) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 10 p. refs
(ASME PAPER 91-GT-400)

A review of inlet planar total pressure waves has been accomplished by the SAE S-16 Committee. The review was conducted to determine the feasibility of developing a consensus methodology that can account for the effect of planar waves on inlet/engine compatibility. The elements of the review included a problem assessment to define the scope and severity of the problem, a discussion of possible approaches to defining a methodology that can relate planar waves to engine response, conclusions, and recommendations. This paper discusses the major findings of the committee effort. Author

A92-15733
ACTIVE STABILIZATION OF MULTISTAGE AXIAL-COMPRESSOR AERODYNAMIC SYSTEM INSTABILITIES
W. M. HOSNY, L. LEVENTHAL, and W. G. STEENKEN (GE Aircraft Engines, Cincinnati, OH) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. refs
(ASME PAPER 91-GT-403)

Active control of multistage axial-compressor aerodynamic instabilities has been studied analytically using a blade-row by blade-row compression system model. The instabilities considered are those which result from a global system instability. The control approach taken is to suppress the instability by actively changing the system damping characteristics. This was accomplished by varying dynamically the compressor stage characteristics to extend the region of the compression system operation. Specifically, the stator row of a compressor stage is actively dithered based on its inlet or exit pressure fluctuation measurement such that the stage characteristics are modified in such a way as to improve the overall system stability. The analytical model and the results of the stator dither study are presented in this paper. The results indicated a slight gain in the compressor stability limit line when the compressor stages are well matched. With increased interstage bleed, resulting in a mismatch between the front and the rear blocks of the compressor, the stabilization results indicated a significant gain in the stability limit line. Author

A92-16093
PREDICTION OF GENERALIZED AERODYNAMIC FORCES FOLLOWING LINEARIZED SUPERSONIC THEORY
A. DUGEAI (ONERA, Chatillon, France) (International Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, June 3-6, 1991) ONERA, TP no. 1991-114, 1991, 12 p. refs
(ONERA, TP NO. 1991-114)

This paper presents the numerical tools which have been developed at ONERA's structural division in order to calculate generalized aerodynamic forces for supersonic aircrafts. A new method is described which is able to calculate aerodynamic forces for bodies following supersonic linearized theory. This method is a mixed finite element-integral equation method whose main features are identical in the steady and in the unsteady cases. The Green's formulation of the linearized problem is treated in a variational way, and it is projected in an approximation space where the unknowns are the values of the potential at each node of a triangular mesh approximating the surface of the body.
Author

A92-16102
HIGH-SPEED IMPULSIVE NOISE AND AERODYNAMIC RESULTS FOR RECTANGULAR AND SWEPT ROTOR BLADE TIP TESTS IN S1-MODANE WIND TUNNEL
C. POLACSEK and P. LAFON (ONERA, Chatillon, France) (European Rotorcraft Forum, 17th, Berlin, Federal Republic of Germany, Sept. 24-27, 1991) ONERA, TP no. 1991-124, 1991, 10 p. refs
(ONERA, TP NO. 1991-124)

This paper presents acoustic and aerodynamic results obtained by comparing two four-bladed rotors equipped with different sets of blade tip shapes: rectangular (rotor 7A) and sweptback with anhedral (rotor 7AD). The data analysis makes it possible to compare the aerodynamic performance of the two rotors and to verify that the shock delocalization in the forward direction is decreased with the sweptback parabolic tip blades (7AD). A gain of 8 dBA on sound pressure level (SPL) is obtained just before delocalization with the rotor 7AD, and the aerodynamic efficiency is improved too. It confirms the interest of the dihedral concept. Aerodynamic and acoustic results constitute a data base for the validation of computer codes under development. Author

A92-16107
THREE-DIMENSIONAL THIN-LAYER AND SPACE-MARCHING NAVIER-STOKES COMPUTATIONS USING AN IMPLICIT MUSCL APPROACH - COMPARISON WITH EXPERIMENTS AND EULER COMPUTATIONS
M. BORREL, P. D'ESPINEY, and C. JOUET (ONERA, Chatillon, France) (Gesellschaft fuer angewandte Mathematik und Mechanik, Royal Academy of Sciences, U.S. Navy, et al., Conference on Numerical Methods in Fluid Dynamics, 9th, Lausanne, Switzerland, Sept. 25-27, 1991) ONERA, TP no. 1991-131, 1991, 11 p. Research supported by DRET. refs
(ONERA, TP NO. 1991-131)

A space-marching and a thin-layer Navier-Stokes unsteady method is presented for supersonic laminar flows. The numerical scheme is based on an upwind implicit scheme for the convective and pressure terms and a centered approximation for the viscous terms. Results on vortex flows around a fuselage with a lenticular section, are compared with available experimental data and with Euler results. To obtain the right vortex pattern, it was found essential to take into account the viscous effects and to use a refined-enough grid. Author

A92-16122
DETAILED ANALYSIS OF WING-NACELLE INTERACTION FOR COMMERCIAL TRANSPORT AIRCRAFT [ANALYSE DETAILLEE DE L'INTERACTION VOILURE-NACELLE D'UN AVION DE TRANSPORT CIVIL]
J. L. GODARD, O.-P. JACQUOTTE (ONERA, Chatillon, France), and D. GISQUET (Aerospatiale, Toulouse, France) (NATO, AGARD, Symposium, Fort Worth, TX, Oct. 7-10, 1991) ONERA, TP no. 1991-152, 1991, 12 p. In French. refs
(ONERA, TP NO. 1991-152)

An experimental setup has been developed to study the wing-nacelle interaction of commercial transports during transonic operation. This stand allows the measurement of the overall loads, pressure distribution on the model, and velocities in the field by laser velocimetry. The analysis gives a better understanding of the wing-nacelle interaction and provides the best comparative elements for modeling calculations. R.E.P.

A92-16125
FORMULATION OF A SIMPLIFIED MODEL OF ROTOR-HORIZONTAL STABILIZER INTERACTIONS AND COMPARISON WITH EXPERIMENTAL MEASUREMENTS
S. WEINSTOCK (ONERA, Chatillon, France) (European Rotorcraft Forum, 17th, Berlin, Federal Republic of Germany, Sept. 24-27, 1991) ONERA, TP no. 1991-157, 1991, 20 p. refs
(ONERA, TP NO. 1991-157)

The aerodynamic interactions of the rotor wake on the horizontal stabilizer can affect strongly the longitudinal dynamics of a helicopter. A good representation of this phenomenon is necessary for helicopter flight mechanics simulation models. A simple rotor wake model using vortex rings is developed in order to calculate these interactions. The results of this model are compared with the experimental measurements conducted at the ONERA S2-Ch wind tunnel on a motorized helicopter scaled model. Author

A92-16129
THE SONIC BOOM AND PROBLEMS RELATED TO SUPERSONIC FLIGHTS OF MILITARY AIRCRAFT [LE BANG ET LES PROBLEMES LIES AUX VOLS SUPERSONIQUES DES AVIONS MILITAIRES]
CHRISTIAN THERY and CLAUDE LECOMTE (ONERA, Chatillon, France) (NATO, AGARD, Meeting, Bonn, Federal Republic of Germany, Oct. 21-25, 1991) ONERA, TP no. 1991-162, 1991, 25 p. In French. refs
(ONERA, TP NO. 1991-162)

The principal features of sonic boom propagation, methods of calculation and some experimental results are presented. The various forms that these booms can take are described, i.e., normal boom and focused booms. Ground effects of sonic booms on populations and structures are discussed and some suggestions are offered on the conduct of overland supersonic flights. R.E.P.

A92-16133
SUPERSONIC STATOR-ROTOR INTERACTION IN A TURBINE STAGE
GILLES BILLONNET (ONERA, Chatillon, France) (International Symposium on Unsteady Aerodynamics, Aeroacoustics, and Aeroelasticity of Turbomachines and Propellers, 6th, University of Notre Dame, IN, Sept. 15-19, 1991) ONERA, TP no. 1991-166, 1991, 15 p. Research supported by SEP and CNES. refs
(ONERA, TP NO. 1991-166)

The supersonic stator-rotor interaction in a simplified turbine stage is simulated by means of a 2D inviscid-flow computation which is carried out on a domain that includes one blade-to-blade passage of the stator and four blade-to-blade passages of the rotor, with a flow periodicity condition imposed on the extreme boundaries of each group. The results indicate that the flow field is highly unsteady and periodic. It is shown that the unsteady effects are very significant on the upper wall of the nozzle, where the shock waves coming from the rotor impinge. Within the rotor, however, the unsteady effects are weak in terms of static pressure fluctuations. I.S.

A92-16139
SOLUTION OF THE COMPRESSIBLE EULER EQUATIONS FOR STEADY FLOWS AROUND HELICOPTER ROTOR BLADES BY AN IMPLICIT SPACE-CENTERED METHOD
J. SIDES and J. C. BONIFACE (ONERA, Chatillon, France) (European Rotorcraft Forum, 17th, Berlin, Federal Republic of Germany, Sept. 24-27, 1991) ONERA, TP no. 1991-177, 1991, 15 p. Research supported by DRET, EEC, Aerospatiale, et al. refs
(ONERA, TP NO. 1991-177)

An implicit space-centered Euler solver previously developed at ONERA for the calculation of steady transonic flows around airfoils and wings is used here for the numerical simulation of steady compressible flows around helicopter rotor blades. For an extension to the problem of a multibladed rotor in hovering flight, the method is formulated in a rotating frame attached to the blades, using the pseudo-unsteady system of the Euler equations derived by assuming that the total rothalpy is constant. The basic 3D wing code is first applied to the calculation of the steady flow past a wall-mounted half wing with swept tip shape, simulating the transonic flow occurring at the tip of a helicopter rotor blade. Then, preliminary numerical results concerning the two-bladed model rotor of the U.S. Army in hovering flight, and obtained in the framework of a global rotor calculation without wake modeling, are presented and compared with experimental data. Author

A92-16140
AERODYNAMIC AND ACOUSTIC CALCULATIONS OF TRANSONIC NONLIFTING HOVERING ROTORS
J. PRIEUR, M. COSTES (ONERA, Chatillon, France), and J. D. BAEDER (U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) ONERA, TP no. 1991-178, 1991, 30 p. refs
(ONERA, TP NO. 1991-178)

An Euler and a Full Potential Solver are compared for a nonlifting transonic hovering rotor. The correlation is very good on the blade, but the aerodynamic disturbances are damped by the Full Potential

Code off the blade tip. The ability of both codes to provide near-field input data for acoustic predictions using Lighthill's Acoustic Analogy is checked. Acoustic results starting from Euler input data show a fairly good correlation with experiment and with direct Euler far-field calculations, even in the case of delocalization. On the contrary, the precision of the Full Potential results is insufficient for that purpose, and further work is needed to improve the code stability and accuracy off the blade. Author

A92-16141
NUMERICAL OPTIMIZATION OF HELICOPTER ROTOR BLADE AIRFOILS USING UNSTEADY AERODYNAMIC CALCULATIONS [OPTIMISATION NUMERIQUE DE PROFILS DE PALE D'HELICOPTERE PAR DES CALCULS AERODYNAMIQUES INSTATIONNAIRES]
H. BEZARD (ONERA, Chatillon, France) ONERA, TP no. 1991-187, 1991, 27 p. In French. Research supported by DRET. refs
(ONERA, TP NO. 1991-187)

An unsteady potential technique is employed in a numerical optimization process to design new rotor blade airfoils. Wave drag is examined by an unsteady momentum integration and viscous drag by an integral boundary layer method to present a simplified validation on a nonlifting case. Constraints on the mean lift coefficient and the maximum velocity peak on the retreating blade size simulate a high-speed forward flight case. It is shown that the designed airfoils have improved steady and unsteady performance. R.E.P.

A92-16457* Analytical Services and Materials, Inc., Hampton, VA.
ON THE NONLINEAR STABILITY OF A HIGH-SPEED, AXISYMMETRIC BOUNDARY LAYER
C. D. PRUETT, LIAN L. NG (Analytical Services and Materials, Inc., Hampton, VA), and GORDON ERLEBACHER (NASA, Langley Research Center; ICASE, Hampton, VA) Physics of Fluids A (ISSN 0899-8213), vol. 3, Dec. 1991, p. 2910-2926. Previously announced in STAR as N91-21099. refs
(Contract NAS1-18605)
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The stability of a high-speed, axisymmetric boundary layer is investigated using secondary instability theory and direct numerical simulation. Parametric studies based on the temporal secondary instability theory identify subharmonic secondary instability as a likely path to transition on a cylinder at Mach 4.5. The theoretical predictions are validated by direct numerical simulation at temporally-evolving primary and secondary disturbances in an axisymmetric boundary-layer flow. At small amplitudes of the secondary disturbance, predicted growth rates agree to several significant digits with values obtained from the spectrally-accurate solution of the compressible Navier-Stokes equations. Qualitative agreement persists to large amplitudes of the secondary disturbance. Moderate transverse curvature is shown to significantly affect the growth rate of axisymmetric second mode disturbances, the likely candidates of primary instability. The influence of curvature on secondary instability is largely indirect but most probably significant, through modulation of the primary disturbance amplitude. Subharamonic secondary instability is shown to be predominantly inviscid in nature, and to account for spikes in the Reynolds stress components at or near the critical layer. Author

A92-16462* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ON THE INTERACTION BETWEEN FIRST- AND SECOND-MODE WAVES IN A SUPERSONIC BOUNDARY LAYER
L. MAESTRELLO (NASA, Langley Research Center, Hampton, VA), A. BAYLISS (Northwestern University, Evanston, IL), and R. KRISHNAN (Vigyan Research Associates, Inc., Hampton, VA) Physics of Fluids A (ISSN 0899-8213), vol. 3, Dec. 1991, p. 3014-3020. refs
(Contract NAS1-18107; NAS1-18605; NSF ASC-87-19573)
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Linear stability theory predicts two or more types of unstable disturbances in a sufficiently high-speed boundary layer. These include the first mode, which is similar to the Tollmien-Schlichting waves found in low-speed flows, and the second mode, which does not depend strongly on the viscosity. Generally, the most unstable first mode is three-dimensional while the most unstable second mode is two-dimensional. The interaction between these two spatially unstable modes are studied by direct solution of the three-dimensional Navier-Stokes equations. It is found that the two-dimensional second mode causes a significant increase in the nonlinearity and in the three-dimensionality of the flowfield. The results suggest that this interaction may accelerate transition for flows where the second mode has a significant growth rate. Author

A92-16668 National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
MACH 4 AND MACH 8 AXISYMMETRIC NOZZLES FOR A HIGH-ENTHALPY SHOCK TUNNEL
P. A. JACOBS (NASA, Langley Research Center; ICASE, Hampton, VA) and R. J. STALKER (Queensland, University, St. Lucia, Australia) Aeronautical Journal (ISSN 0001-9240), vol. 95, Nov. 1991, p. 324-334. Research supported by Australian Research Council. Previously announced in STAR as N91-20146. refs
(Contract NAGW-674; NAS1-18605)
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The performance of two axisymmetric nozzles which were designed to produce uniform, parallel flow with nominal Mach numbers of 4 and 8 is examined. A free-piston-driven shock tube was used to supply the nozzle with high-temperature, high-pressure test gas. The inviscid design procedure treated the nozzle expansion in two stages. Close to the nozzle throat, the nozzle wall was specified as conical and the gas flow was treated as a quasi-one-dimensional chemically-reacting flow. At the end of the conical expansion, the gas was assumed to be calorically perfect, and a contoured wall was designed (using method of characteristics) to convert the source flow into a uniform and parallel flow at the end of the nozzle. Performance was assessed by measuring Pitot pressures across the exit plane of the nozzles and, over the range of operating conditions examined, the nozzles produced satisfactory test flows. However, there were flow disturbances in the Mach 8 nozzle flow that persisted for significant times after flow initiation. Author

A92-16679
THREE-DIMENSIONAL SINGULARITY OF FLOW STRUCTURE IN AN UNDEREXPANDED SUPERSONIC JET [TREKHMERNAIA OSOBENNOST' STRUKTURY TECHENIIA V SVERKHZVUKOVOI NEDORASSHIRENNOI STRUE]
V. I. ZAPRIAGAEV and A. V. SOLOTCHIN PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), July-Aug. 1991, p. 42-47. In Russian. refs
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Structural inhomogeneities in underexpanded supersonic jets were investigated experimentally by using the photographic method and by measuring full and static pressures in the flow region between a suspended compression shock and the jet boundary in the compressed layer. The results obtained are found to be consistent with the hypothesis about the existence of formations of the Taylor-Goertler vortex type in the compressed layer of nonisobaric jets. V.L.

A92-16680
CHANGING THE STRUCTURE AND IMPROVING THE AERODYNAMIC CHARACTERISTICS OF SUPERSONIC FLOW PAST BODIES THROUGH EJECTION OF A GAS JET WITH PARTICLES [IZMENENIE STRUKTURY I ULUCHSHENIE AERODINAMICHESKIKH KHARAKTERISTIK SVERKHZVUKOVOGO OBTEKANIIA TEL ZA SCHET VYDUVA IS NIKH STRUI GAZA S CHASTITSAMI]
N. P. GRIDNEV PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), July-Aug. 1991, p. 47-50.

In Russian. refs
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Supersonic flow past bodies of revolution (a cone-cylinder configuration and a cylinder) and their aerodynamic characteristics are investigated analytically in the case where a jet of a gas with solid particles is ejected from the surface of the body. The treatment is based on the numerical solution of a full system of Navier-Stokes equations for a viscous heat-conducting gas and employs a third-order difference scheme. Optimal ejection parameters are determined. V.L.

A92-16681
SELF-OSCILLATORY INTERACTION OF AN UNDEREXPANDED JET WITH AN OBSTACLE IN THE PRESENCE OF A SUPERSONIC WAKE [AVTOKOLEBATEL'NYI REZHIM VZAIMODEISTVIIA NEDORASSHIRENNOI STRUI S PREGRADOI PRI NALICHII SVERKHZVUKOVOGO SPUTNOGO POTOKA]

G. F. GORSHKOV, V. N. USKOV, and A. P. USHAKOV PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), July-Aug. 1991, p. 50-58. In Russian. refs
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Experiments were carried out in a supersonic wind tunnel in an effort to gain a better understanding of the mechanisms of the self-oscillatory regime of the interaction between a supersonic jet and a plane obstacle in the presence of a supersonic wake. In the experiments, the self-oscillatory regime of jet-obstacle interaction was observed under conditions where the existence of an acoustic wave feedback was ruled out. Without denying the effect of the external acoustic feedback, it is demonstrated that this feedback is not the principal mechanism of the formation of nonstationary flow in the shock layer. V.L.

A92-16682
FEEDBACK MECHANISM OF SELF-OSCILLATIONS IN THE CASE OF AN UNDEREXPANDED SUPERSONIC JET IMPINGING ON A PLANE OBSTACLE [O MEKHANIZME OBRATNOI SVIAZI V AVTOKOLEBANIIAKH PRI NATEKANII SVERKHZVUKOVOI NEDORASSHIRENNOI STRUI NA PLOSKUIU PREGRADU]

V. N. GLAZNEV PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), July-Aug. 1991, p. 59-63. In Russian. refs
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Self-oscillations excited during the interaction of an underexpanded supersonic jet with a plane obstacle were investigated experimentally using a jet of cold air at Mach 1.5. The results obtained are compared with the results of earlier experimental and theoretical studies. It is argued that, contrary to the conclusion of Gorshkov et al. (1991), the external acoustic feedback is a major factor determining the amplitude-frequency characteristics of the self-oscillations. V.L.

A92-16684
STABILITY OF A VISCOUS COMPRESSIBLE SHEAR LAYER WITH A TEMPERATURE DROP [USTOICHIVOST' VIAZKOGO SZHIMAEMOGO SLOIA SDVIGA S PEREPADOM TEMPERATUR]

A. N. KUDRIAVTSEV and A. S. SOLOV'EV PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), July-Aug. 1991, p. 88-95. In Russian. refs
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The stability of a free shear layer formed as a result of the mixing of two parallel flows of a viscous compressible gas is investigated analytically, with allowance made for the difference in the temperatures of the the mixing flows. The problem is solved by the orthogonalization method using linearized Navier-Stokes equations for a compressible gas. Three unstable modes of discrete spectrum perturbations are identified. Neutral stability curves are presented. V.L.

A92-16705
ASYMPTOTICS OF THE UPPER BRANCH OF THE NEUTRAL CURVE AT SUBSONIC AND TRANSONIC EXTERNAL FLOW VELOCITIES [ASIMPTOTIKA VERKHNEI VETVI TSENTRAL'NOI KRIVOI PRI DO- I TRANSZVUKOVYKH SKOROSTIAKH VNESHNEGO POTOKA]

V. I. ZHUK Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), vol. 31, Nov. 1991, p. 1716-1730. In Russian. refs
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The method of matched asymptotic expansions is used to solve stability equations describing the Tollmien-Schlichting wave in a boundary layer of a compressible gas with a five-layer structure of the perturbed velocity field. The limiting behavior of the upper branch of the neutral curve is determined for large Reynolds numbers. The perturbation increment is calculated in the vicinity of the neutral curve. V.L.

A92-16812
ANALYSIS OF TRANSONIC FLOW OVER PLANE COMPRESSOR CASCADES USING THE LARGE-PARTICLE METHOD [ANALIZ TRANSZVUKOVOGO OBTEKANIIA PLOSKIKH KOMPRESSORNYKH RESHETOK METODOM KRUPNYKH CHASTITS]

L. G. BOIKO, V. N. ERSHOV, A. E. DEMIN, and D. V. KALIAMIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1990, p. 44-47. In Russian. refs
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The application of the large-particle finite difference method to the calculation of compressible flow in a plane compressor cascade is reported. The statement of the problem and details of the solution procedure are presented. Numerical calculations are made for subcritical and supercritical flow regimes at different angles of attack. V.L.

A92-16813
A DISCRETE VORTEX STUDY OF STATIONARY FLOW PAST THREE-DIMENSIONAL LIFTING SYSTEMS AT SUBSONIC AND SUPERSONIC VELOCITIES [ISSLEDOVANIE METODOM DISKRETNYKH VIKHREI STATSIONARNOGO OBTEKANIIA PROSTRANSTVENNYKH NESUSHCHIKH SISTEM PRI DO- I SVERKHZVUKOVYKH SKOROSTIAKH POTOKA]

A. M. VALUISKII, S. S. GRAS'KIN, and V. A. PODOBEDOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1990, p. 48-50. In Russian. refs
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The discrete vortex method is applied to the analysis of stationary flow past three-dimensional lifting systems, such as multiple-airfoil wings, at subsonic and supersonic velocities. A unified mathematical model for the analysis of both subsonic and supersonic flow past wings of this type is developed. Examples of calculations are presented. V.L.

A92-16814
DIFFUSER EFFICIENCY ESTIMATION PARAMETERS [PARAMETRY OTSENKI EFFEKTIVNOSTI DIFFUZOROV]

B. S. VINOGRADOV and I. V. BABCHENKO Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1990, p. 50-56. In Russian. refs
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The currently used parameters for estimating the pressure characteristics and efficiency of diffusers are examined with reference to data in the literature. Formulas relating the pressure recovery and drag coefficients are proposed, as are expressions for calculating the drag of supersonic diffusers from the known drag coefficients of the components. V.L.

A92-16815
SYNTHESIS OF WING PROFILES FROM CHORD VELOCITY DIAGRAMS USING QUASI-SOLUTIONS FOR INVERSE BOUNDARY VALUE PROBLEMS [POSTROENIE KRYLOVYKH PROFILEI PO KHORDOVOI DIAGRAMME SKOROSTI S ISPOL'ZOVANIEM KVAZIRESHENII OBRATNYKH KRAEVYKH ZADACH]
M. S. GALIAVIEVA Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1990, p. 56-59. In Russian. refs
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The problem considered here concerns the synthesis of an isolated wing profile in plane stationary flow of an ideal incompressible fluid on the basis of the velocity distribution prescribed on the surface as a function of the Cartesian coordinate x. An iteration procedure for solving the problem is proposed which makes it possible to obtain a closed profile with minimum changes in the initial data. The solvability conditions are satisfied by using the quasi-solution method for inverse boundary value problems. V.L.

A92-16817
A MODEL OF GASDYNAMIC LOADS ON AN OSCILLATING NOZZLE SHELL [MODELI GAZODINAMICHESKIKH NAGRUZOK NA KOLEBLIUSHCHEISIA OBOLOCHKE SOPLA]
A. A. SERGIENKO Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1990, p. 63-67. In Russian. refs
Copyright

For jet nozzles of large expansion ratios, models are examined which describe gasdynamic loads generated in the case of infinite uniform plane flow past an oscillating corrugated plate with a periodic small displacement structure. The supercritical and subcritical flow regions are determined for traveling and stationary displacement waves, and critical flow regimes are identified in relation to the flow velocity, oscillation frequency, and wavelength ratio of the periodic structure. V.L.

A92-16818
DETUNING FROM THE NATURAL RESONANCES OF THE BLADE IN THE COMPUTER-AIDED DESIGN OF BLADE ROWS FOR AXIAL-FLOW COMPRESSORS [OTSTROIKA OT REZONANSOV SOBSTVENNYKH KOLEBANII PERA V SAPR LOPATOCHNYKH VENTSOV OSEVYKH KOMPRESSOROV]
V. V. BIBIKOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1990, p. 67-71. In Russian. refs
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An algorithm is developed for the frequency detuning of blades during the computer-aided design of blade rows for axial-flow compressors. The algorithm makes it possible to satisfy the gasdynamic and static strength requirements. The performance of the software implementing the algorithm is evaluated. V.L.

A92-17178* Sverdrup Technology, Inc., Brook Park, OH.
UNSTEADY BLADE-SURFACE PRESSURES ON A LARGE-SCALE ADVANCED PROPELLER - PREDICTION AND DATA
M. NALLASAMY (Sverdrup Technology, Inc., Brook Park, OH) and J. F. GROENEWEG (NASA, Lewis Research Center, Cleveland, OH) Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, Nov.-Dec. 1991, p. 866-872. Previously cited in issue 21, p. 3302, Accession no. A90-47220. refs
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A92-17194
STAGE-BY-STAGE POSTSTALL COMPRESSION SYSTEM MODELING TECHNIQUE
M. W. DAVIS, JR. (Sverdrup Technology, Inc., Arnold AFB, TN) and W. F. O'BRIEN (Virginia Polytechnic Institute and State University, Blacksburg) Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, Nov.-Dec. 1991, p. 997-1005. Research sponsored by USAF. Previously cited in issue 20, p. 3143, Accession no. A87-45397. refs
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A92-17195
ENHANCED MIXING OF SUPERSONIC JETS
T. G. TILLMAN, W. P. PATRICK, and R. W. PATERSON (United Technologies Research Center, East Hartford, CT) Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, Nov.-Dec. 1991, p. 1006-1014. Research supported by United Technologies Corp. Previously cited in issue 19, p. 3175, Accession no. A88-47071. refs
(Contract N00014-85-C-0506)
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A92-17196
EULER FLOW ANALYSIS OF TURBINE POWERED SIMULATOR AND FANJET ENGINE
NAOKI HIROSE, KEISUKE ASAI (National Aerospace Laboratory, Tokyo, Japan), RYUMA KAWAMURA (Nihon University, Funabashi, Japan), and KATUYA IKAWA Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, Nov.-Dec. 1991, p. 1015-1022. Previously cited in issue 18, p. 2755, Accession no. A89-42063. refs
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A92-17197
TANGENTIAL MASS ADDITION FOR SHOCK/BOUNDARY-LAYER INTERACTION CONTROL IN SCRAMJET INLETS
M. E. WHITE, R. E. LEE, M. W. THOMPSON, A. CARPENTER (Johns Hopkins University, Laurel, MD), and W. J. YANTA (U.S. Navy, Naval Surface Warfare Center, White Oak, MD) (International Symposium on Air Breathing Engines, 9th, Athens, Greece, Sept. 3-8, 1989, Proceedings. Volume 2, p. 815-823) Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, Nov.-Dec. 1991, p. 1023-1029. Research supported by U.S. Navy and USAF. Previously cited in issue 02, p. 139, Accession no. A90-12586. refs
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A92-17198
INVISCID ANALYSIS OF A DUAL MODE SCRAMJET INLET
YEU-CHUAN HSIA, BENJAMIN J. GROSS, and J. P. ORTWERTH (Rockwell International Corp., Canoga Park, CA) Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, Nov.-Dec. 1991, p. 1030-1035. Research supported by Rockwell International Corp. Previously cited in issue 20, p. 3083, Accession no. A89-47011. refs
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N92-11969 ESDU International Ltd., London (England).
EFFECT OF TWIN FINS ON ISOLATED TAILPLANE LIFT-CURVE SLOPE
Jul. 1991 7 p
(ESDU-91009; ISBN-0-85679-771-5; ISSN-0141-397X) Avail: ESDU

ESDU 91009 discusses a method that is based on determining the effective (increased) aspect ratio of the tailplane due to the end plate effect of the fins. ESDU 70011 is then used to estimate the lift curve slope for that effective aspect ratio. Wind tunnel data drawn from the literature for a wide range of configurations were used to correlate the effective aspect ratio (determined using ESDU 70011) as a function of the ratio fin height/tailplane span and fin spanwise position. The data were correlated to within 5 percent and applied to straight tapered tailplanes of taper ratio between 1 and 0.4 (tip chord/centerline chord) and mid chord sweep up to 45 degrees, for any fin planform, and are independent of fin vertical location on the tailplane. For swept tailplanes the correlation only applies when the fin chord extends well forward of the tailplane leading edge (by at least 0.25 chord). It is restricted to attached flow at subcritical speeds. The ranges of the geometries for the test data used in the correlation are tabulated, sketches show plots comparing predicted with experimental results, and a worked example illustrates the use of the data. ESDU

N92-11970 ESDU International Ltd., London (England).
MAXIMUM LIFT OF WINGS WITH TRAILING-EDGE FLAPS AT LOW SPEEDS
Aug. 1991 21 p
(ESDU-91014; ISBN-0-85679-776-6; ISSN-0141-397X) Avail: ESDU

A method is given that involves the calculation of two components: the increment in maximum lift coefficient due to flaps is added to the maximum lift coefficient for the wing with flaps undeployed determined from ESDU 89034. The first component is calculated using ESDU 85033 applied to the most highly loaded section, factored for effects of aspect ratio, taper ratio, and wing sweep in addition to flap part span effects. The method was developed using wind tunnel data from many sources for a wide range of planform parameters (aspect ratios from 3 to 9 and leading edge sweep up to 50 degs) for which it was found to correlate the predicted increment generally within 10 pct. and the maximum lift of the wing with flaps deployed to within 5 pct. It applies for freestream Mach numbers less than 0.25 for plain, split, or single or multi-slotted flaps. Sketches of predictions plotted against test results illustrate the quality of the estimation and a detailed worked example illustrates the use of the method. ESDU

N92-11972# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Direction de la Physique Generale.
THERMOGRAPHIC GUST WIND TUNNEL MEASUREMENTS Final Report [MESURES THERMOGRAPHIQUES EN SOUFFLERIE A RAFALES. RAPPORT FINAL]
M. GIRARD Aug. 1990 41 p In FRENCH
(Contract DRET-BC-87-001-54)
(ONERA-RF-31/3409-PY; ETN-91-90087) Avail: NTIS HC/MF A03

A test campaign at the R3Ch gust wind tunnel using a space plane type model is reported. Information storage problems are discussed. The results are transferred to the French aerodynamic management (OA) in magnetic tape form. Additionally, the image inventory analysis methods are transferred to the OA. ESA

N92-11973# Technische Univ., Eindhoven (Netherlands). Vakgroep Transportfysica.
ON THE LIMITATIONS OF FROUDE'S ACTUATOR DISC CONCEPT Ph.D. Thesis
GIJSBERTUS ARNOLDUS VANKUIK 1991 151 p
(ETN-91-90136) Avail: NTIS HC/MF A08

The question of whether the actuator disc including edge forces is a better representation of the action of conventional helicopter or wind turbine rotors than Froude's mathematical model is addressed. The load on the chordwise bound vorticity of the rotor blade is shown not to perform work, which conflicts with Froude's assumption of the load converting power being equal to the total load. An experiment on a model rotor in hover shows the load converting power to be smaller than the total load on the rotor. It is concluded that the addition of edge forces to Froude's concept improves the performance prediction for rotors significantly, although discrepancies between prediction and measurement remain. The actuator disc itself is addressed and the question of whether the edge forces are an inherent part of the load instead of merely an addition to Froude's concept is addressed numerically and analytically to improve the representation of real rotors. A nonlinear viscous finite element calculation is set up for the flow of a two dimensional actuator strip with a smooth load distribution. ESA

N92-11975# National Research Council of Canada, Ottawa (Ontario). Inst. for Aerospace Research.
WIND TUNNEL TESTS ON A4, A4.1, AND A4.2 2-D AIRFOIL MODELS IN THE IAR 5-FT. WIND TUNNEL: BOEING COMMERCIAL AIRPLANE COMPANY AND INSTITUTE FOR AEROSPACE RESEARCH COLLABORATIVE WORK PROGRAM
Y. NISHIMURA Nov. 1990 683 p Sponsored in part by Boeing Commercial Airplane Co.
(NRC-IAR-C3; NRC-LTR-HA-5X5/0196; CTN-91-60255) Avail: NTIS HC/MF A99

A wind tunnel project was undertaken to obtain aerodynamic data to investigate the influence of the wind tunnel sidewall boundary layer effects by testing models with different aspect ratios. Wind tunnel investigations were performed on three airfoil models with the same airfoil section but with different chord lengths. The tests were performed over a Mach number range from 0.70 to 0.80 with the flow at a chord Reynolds number of 14 million. This project was undertaken as a collaborative wind tunnel program between Boeing Commercial Airplane Company and the Institute of Aerospace Research (Canada) to investigate the wall interference effects encountered during 2-D tests on transonic airfoils. The report includes some of the pertinent features of the test procedures, and the test parameters and variables used in the data processing procedures, to provide the information necessary to interpret the processed data. The analyses of the data are not included. CISTI

N92-11976# National Research Council of Canada, Ottawa (Ontario). High Speed Aerodynamics Lab.
THE BCAC/IAR COLLABORATIVE RESEARCH PROGRAM TO INVESTIGATE THE SIDEWALL BOUNDARY LAYER EFFECTS IN THE IAR/NRC 2-D HIGH REYNOLDS NUMBER TEST FACILITY Preliminary Report
Y. NISHIMURA 11 Jan. 1991 110 p
(NRC-HSA-434; CTN-91-60256) Avail: NTIS HC/MF A06

The Institute of Aerospace Research (IAR) and the Boeing Commercial Airplane Company (BOAC) formulated a collaborative wind tunnel program to investigate the degree of sidewall boundary layer effects by investigations on 2-D airfoil models with different aspect ratios. The first part of the plan was to examine sidewall boundary layer effects in the IAR 2-D High Reynolds Number Test Facility by acquiring data for three different airfoil models all with the same airfoil section but each with different chord lengths to provide three different aspect configurations. Secondly, another model with the same airfoil cross section and a chord length equal to that of the largest of the three earlier models but with a longer span is to be installed in the 3-D transonic test section of the IAR Blowdown Wind Tunnel as a 2-D model. The ranges of these chord and span dimensions are chosen to represent a fairly wide spectrum of model sizes and the results may determine the best size range for 2-D models to be tested in the IAR facility with minimal sidewall boundary layer effects. The tests of the three smaller models at the 2-D facility have been completed and this report presents the results from these investigations. CISTI

N92-11977*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
INVESTIGATION OF THE AEROELASTIC STABILITY OF THE AFW WIND-TUNNEL MODEL USING CAP-TSD
WALTER A. SILVA and ROBERT M. BENNETT Sep. 1991 12 p Presented at the AGARD Specialists Meeting, San Diego, CA, 6-11 Oct. 1991
(NASA-TM-104142; NAS 1.15:104142) Avail: NTIS HC/MF A03 CSCL 01A

The Computational Aeroelasticity Program - Transonic Small Disturbance (CAP-TSD) code, developed at the NASA Langley Research Center, is applied to the Active Flexible Wing (AFW) wind tunnel model for prediction of the model's transonic aeroelastic behavior. A semi-span computational model is used for evaluation of symmetric motions and a full span model is used for evaluation of antisymmetric motions. Static aeroelastic solutions using CAP-TSD are computed. Dynamic (flutter) analyses are then performed as perturbations about the static aeroelastic deformations and presented as flutter boundaries in terms of Mach number and dynamic pressure. Flutter boundaries that take into account modal refinements, vorticity and entropy corrections, antisymmetric motions and sensitivity to the modeling of the wing tip ballast stores are also presented and compared with experimental flutter results. Author

N92-11980# Ecole Nationale Superieure de Mecanique et d'Aerotechnique, Poitiers (France). Lab. d'Aerodynamique.
NONSTATIONARY FLIGHT AERODYNAMICS IN A TURBULENT ENVIRONMENT Final Summary Report [AERODYNAMIQUE INSTATIONNAIRE DU VOL EN MILIEU TURBULENT. RAPPORT DE SYNTHESE FINAL]
P. ARDONCEAU and F. MICHELI Jul. 1990 72 p In FRENCH
(Contract DRET-85-072)
(ETN-91-90102) Avail: NTIS HC/MF A04

Experimental results of wind tunnel tests on a rectangular wing panel and on a half delta wing submitted to oscillations are described. Charts of nonstationary wing pressures, of flow deflection at the trailing edge of the wing and visualizations of the wing wake are presented. A second series of tests carried out on a flying scale model of the Rafale aircraft are described. The wing pressures and local flow over the wing are quantified for flight close to the ground and in meteorologically perturbed conditions. The results of these tests are presented. ESA

N92-11981# Centre d'Etudes Aerodynamiques et Thermiques, Poitiers (France).
CONTROL ASPECTS OF THE TRANSITION FROM TRANSVERSAL TO TRANSONIC FLOW, STEP EFFECTS Final Report [CONTROLE DE LA TRANSITION TRANSVERSALE EN TRANSSONIQUE PAR ASPIRATION: EFFET DE MARCHES. RAPPORT FINAL]
R. LEBLANC and H. GAREM Dec. 1990 19 p In FRENCH
(Contract DRET-89-1170)
(ETN-91-90106) Avail: NTIS HC/MF A03

Transonic wind tunnel tests are used to study transitions along an arrowhead shaped wing and the control of this wing by suction along it's leading edge. The effects of ascendent and descendent steps is considered. The goal of the research is that of delaying the laminar surface layer transitions triggered by the transverse pressure gradient in order to reduce the viscous trail of the airplanes, thus reducing their overall operating costs and increasing their operating range. The wind tunnel tests carried out in a scale model of an arrowhead shaped wing indicate that step effects lead to too much flow perturbation over the wing. ESA

N92-11982# Institut de Mecanique des Fluides de Lille (France).
PHENOMENOLOGICAL MODELING OF THE WAKE PRODUCED BY A STRAIGHT TWO DIMENSIONAL BASE IN SUBSONIC FLOW [MODELISATION PHENOMENOLOGIQUE DU SILLAGE D'UN CULOT DROIT BIDIMENSIONNEL EN ECOULEMENT SUBSONIQUE]
O. RODRIGUEZ 21 Dec. 1990 59 p In FRENCH
(Contract DRET-89-003-07)
(REPT-90/59; ETN-91-90109) Avail: NTIS HC/MF A04

Wake turbulence phenomena at subsonic speeds are studied. The aerodynamic phenomena leading to detachment and large spinning structures in wakes is given particular attention. A better understanding of these phenomena is needed to comprehend wake reduction measures and jet homogenization techniques. The results of numerous wind tunnel tests are presented. They show that the development of spinning eddies of turbulence is similar no matter the height of the base or the Reynolds or Mach number involved. ESA

N92-11983*# Cornell Univ., Ithaca, NY.
FLOW VISUALIZATION AND FLOW FIELD MEASUREMENTS OF A 1/12 SCALE TILT ROTOR AIRCRAFT IN HOVER
CHARLES D. COFFEN, ALBERT R. GEORGE, HAL HARDINGE, and RYAN STEVENSON 1991 29 p
(Contract NAG2-554)
(NASA-CR-189456; NAS 1.26:189456) Avail: NTIS HC/MF A03 CSCL 01A

The results are given of flow visualization studies and inflow velocity field measurements performed on a 1/12 scale model of the XV-15 tilt rotor aircraft in the hover mode. The complex recirculating flow due to the rotor-wake-body interactions characteristic of tilt rotors was studied visually using neutrally buoyant soap bubbles and quantitatively using hot wire anemometry. Still and video photography were used to record the flow patterns. Analysis of the photos and video provided information on the physical dimensions of the recirculating fountain flow and on details of the flow including the relative unsteadiness and turbulence characteristics of the flow. Recirculating flows were also observed along the length of the fuselage. Hot wire anemometry results indicate that the wing under the rotor acts to obstruct the inflow causing a deficit in the inflow velocities over the inboard region of the model. Hot wire anemometry also shows that the turbulence intensities in the inflow are much higher in the recirculating fountain reingestion zone. Author

N92-11984*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
AN ASSESSMENT AND APPLICATION OF TURBULENCE MODELS FOR HYPERSONIC FLOWS
T. J. COAKLEY, J. R. VIEGAS, P. G. HUANG, and M. W. RUBESIN 1990 25 p Presented at the Ninth National Aero-Space Plane Technology Symposium, 1-2 Nov. 1990
(NASA-TM-105124; NAS 1.15:105124; PAPER-106) Avail: NTIS HC/MF A03 CSCL 01A

The current approach to the Accurate Computation of Complex high-speed flows is to solve the Reynolds averaged Navier-Stokes equations using finite difference methods. An integral part of this approach consists of development and applications of mathematical turbulence models which are necessary in predicting the aerothermodynamic loads on the vehicle and the performance of the propulsion plant. Computations of several high speed turbulent flows using various turbulence models are described and the models are evaluated by comparing computations with the results of experimental measurements. The cases investigated include flows over insulated and cooled flat plates with Mach numbers ranging from 2 to 8 and wall temperature ratios ranging from 0.2 to 1.0. The turbulence models investigated include zero-equation, two-equation, and Reynolds-stress transport models. Author

N92-11985*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ON SIMPLE AERODYNAMIC SENSITIVITY DERIVATIVES FOR USE IN INTERDISCIPLINARY OPTIMIZATION
ROBERT V. DOGGETT, JR. Aug. 1991 18 p
(NASA-TM-104145; NAS 1.15:104145) Avail: NTIS HC/MF A03 CSCL 01A

Low-aspect-ratio and piston aerodynamic theories are reviewed as to their use in developing aerodynamic sensitivity derivatives for use in multidisciplinary optimization applications. The basic equations relating surface pressure (or lift and moment) to normal wash are given and discussed briefly for each theory. The general means for determining selected sensitivity derivatives are pointed out. In addition, some suggestions in very general terms are included as to sample problems for use in studying the process of using aerodynamic sensitivity derivatives in optimization studies. Author

N92-12994*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
WIND TUNNEL INVESTIGATION OF THE INTERACTION AND BREAKDOWN CHARACTERISTICS OF SLENDER WING VORTICES AT SUBSONIC, TRANSONIC, AND SUPERSONIC SPEEDS
GARY E. ERICKSON Washington Nov. 1991 226 p
(NASA-TP-3114; L-16803; NAS 1.60:3114) Avail: NTIS HC/MF A11 CSCL 01/1

The vortex dominated aerodynamic characteristics of a generic 65 degree cropped delta wing model were studied in a wind tunnel at subsonic through supersonic speeds. The lee-side flow fields over the wing-alone configuration and the wing with leading edge extension (LEX) added were observed at M (infinity) equals 0.40 to 1.60 using a laser vapor screen technique. These results were correlated with surface streamline patterns, upper surface static pressure distributions, and six-component forces and moments.

The wing-alone exhibited vortex breakdown and asymmetry of the breakdown location at the subsonic and transonic speeds. An earlier onset of vortex breakdown over the wing occurred at transonic speeds due to the interaction of the leading edge vortex with the normal shock wave. The development of a shock wave between the vortex and wing surface caused an early separation of the secondary boundary layer. With the LEX installed, wing vortex breakdown asymmetry did not occur up to the maximum angle of attack in the present test of 24 degrees. The favorable interaction of the LEX vortex with the wing flow field reduced the effects of shock waves on the wing primary and secondary vortical flows. The direct interaction of the wing and LEX vortex cores diminished with increasing Mach number. The maximum attainable vortex-induced pressure signatures were constrained by the vacuum pressure limit at the transonic and supersonic speeds.
Author

N92-12995 North Carolina State Univ., Raleigh.
WALL INTERFERENCE CALCULATION IN A TRANSONIC WIND TUNNEL WITH DISCRETE SLOTS Ph.D. Thesis
JASSIM ABBASS AL-SAADI 1991 151 p
Avail: Univ. Microfilms Order No. DA9123341

A computational simulation of a transonic wind-tunnel test section with longitudinally slotted walls is developed. The slot model includes nonlinear slot-discreteness and dynamic-pressure effects as well as a plenum pressure constraint. The solution is performed using a finite-difference method which solves an extended transonic small disturbance equation. The walls serve as the outer boundary conditions in the relaxation technique with an interaction procedure used at the slotted walls. The technique is predictive in that measured boundary pressures are not required in establishing the wall conditions. Measured wall pressures are only used to assess the accuracy of the simulation. The method is also capable of calculating a free-air solution as well as solutions employing the classical homogeneous wall conditions. Wall interference effects are determined by comparing test-section and free-air calculations. The simulation is used to examine two commercial transport aircraft models at both zero-lift and cruise conditions. Although the plenum pressure has a significant effect on the solution, little effect of slot discreteness if found with the models currently considered. At cruise conditions the wall interference results in errors on the order of one percent in the lift, drag, and pitching moment. The three-dimensional nature of the interference is shown by examining the wing pressure distributions. The walls induce an error in the position of the wing shock wave which is found to vary along the wing. It is concluded that the traditional concept of wall-interference corrections to Mach number and angle of attack may not be suitable for transonic conditions. Dissert. Abstr.

N92-12996# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Fluid Dynamics Panel.
VORTEX FLOW AERODYNAMICS
Jul. 1991 537 p In ENGLISH and FRENCH Symposium held in Scheveningen, Netherlands, 1-4 Oct. 1990
(AGARD-CP-494; ISBN-92-835-0623-5) Copyright Avail: NTIS HC/MF A23; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The AGARD Fluid Dynamics Panel sponsored this symposium to provide an update review of the aerodynamic effects of separation-induced vortex flows on the design and off-design performance of fighter aircraft. A better understanding is needed to predict and control these vortex flows throughout the flight envelope at subsonic, transonic, and supersonic speeds, and especially during high lift operations for take-offs, landings, and sustained and instantaneous maneuvers. Topics of interest included vortex development and burst, modeling and validation of the full range of analytic methods, slender-body vortex flows at high angles of attack, vortex control and management, and unsteady vortex flow effects. In addition to the symposium papers, the results of the round table discussion are presented.

N92-12997# National Aerospace Lab., Amsterdam (Netherlands).
MODELING AND NUMERICAL SIMULATION OF VORTEX FLOW IN AERODYNAMICS
H. W. M. HOEIJMAKERS *In* AGARD, Vortex Flow Aerodynamics 46 p Jul. 1991 Sponsored in part by the Netherlands Agency for Aerospace Programs (NIVR) for the Netherlands Ministry of Defence
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A review is presented of mathematical models of different levels of approximation and their application to the numerical simulation of vortical flows occurring in subsonic and transonic aircraft aerodynamics. Computational methods for predicting the downstream development of vortex wakes are covered as well as methods for simulating the detailed characteristics of configurations with leading-edge or body vortices.The emphasis is on the later, strong-interaction type of vortical flows. Promising developments related to presently used methods are discussed in some detail. The possibilities, limitations, and prospects for improving the methods are indicated and results of various methods are discussed. Also considered are some more fundamental aspects of the numerical simulation of phenomena such as separation at sharp and round leading edges, separation at a smooth part of a surface, the structure of the leading-edge vortex, and the merging of two vortices. Author

N92-12998# Royal Aircraft Establishment, Farnborough (England).
COMPARISON OF SOLUTION OF VARIOUS EULER SOLVERS AND ONE NAVIER-STOKES SOLVER FOR THE FLOW ABOUT A SHARP-EDGED CROPPED DELTA WING
B. R. WILLIAMS, W. KORDULLA, M. BORSI, and H. W. M. HOEIJMAKERS *In* AGARD, Vortex Flow Aerodynamics 12 p Jul. 1991 Previously announced as N91-30106 Sponsored in part by the Ministry of Defence, England; German Ministry of Defence; Italian Ministry of Defence; and the Netherlands Agency for Aerospace Programs for the Ministry of Defence
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For the flow about a sharp-edged cropped 65-deg delta wing numerical solutions obtained with different Euler methods are compared with each other, with the numerical solution of a Reynolds-averaged Navier-Stokes method, and with experimental data. At the selected free-stream Mach number of 0.85 and angle of attack of 10 deg the flow features a leading-edge vortex, is transonic, but contains weak shocks only. The results of the Euler methods have been obtained on one and the same C-H type of grid with close to 300,000 cells. This investigation, carried out within the framework of a four-nation collaborative program, indicates that for the test case considered there are, from a theoretical point of view, significant differences between results from different Euler methods, even if artificial dissipation is minimized. However, the correlation of the Euler solutions with experimental data shows much larger differences due to the failure to represent secondary separation in the Euler methods and is therefore unsatisfactory. The results of the Reynolds-averaged Navier-Stokes method demonstrate an improved correlation of theory and experiment. Author

N92-12999# Aeritalia S.p.A., Turin (Italy).
VORTICAL FLOW SIMULATION BY USING STRUCTURED AND UNSTRUCTURED GRIDS
M. BORSI, L. FORMAGGIA, E. HETTENA, S. SANTILLAN, V. SELMIN, and S. TARDITI *In* AGARD, Vortex Flow Aerodynamics 12 p Jul. 1991 Previously announced as N91-30107
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Two Euler equation solvers based on finite volume formulations on structured and unstructured grids are applied to the simulation of transonic vortical flow around a delta wing-body configuration. The mesh generation techniques are described, some details on

the flow solvers are given, and a comparison between the methods is presented. Author

N92-13000# National Aerospace Lab., Amsterdam (Netherlands).
ANALYSIS OF RESULTS OF AN EULER-EQUATION METHOD APPLIED TO LEADING-EDGE VORTEX FLOW
J. I. VANDENBERG, H. W. M. HOEIJMAKERS, and J. M. J. W. JACOBS *In* AGARD, Vortex Flow Aerodynamics 12 p Jul. 1991 Sponsored in part by the Netherlands Agency for Aerospace Programs (NIVR) for the Netherlands Ministry of Defence
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The flow about a 65-deg sharp-edged cropped delta wing with and without an under-wing body is simulated by solving the Euler equations. Results are presented for the wing-body configuration at a transonic free-stream Mach number at incidences ranging from 10 to 20 deg for which in the flow field above the wing a strong vortex develops as well as shocks for the high incidence of 20 deg. Results for subsonic to transonic free-stream Mach numbers at high incidence are obtained for the wing-alone configuration for which in the presence of a strong vortex, at transonic free-stream Mach number, shocks appear in the solution. For the wing-body configuration, the computational results are compared with experimental data, and the solution in the near wake is investigated. Author

N92-13001# *Technische Univ., Delft (Netherlands). Faculty of* Aerospace Engineering.
EXPERIMENTAL AND NUMERICAL INVESTIGATION OF THE VORTEX FLOW OVER A DELTA WING AT TRANSONIC SPEED
E. M. HOUTMAN and W. J. BANNINK *In* AGARD, Vortex Flow Aerodynamics 11 p Jul. 1991
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The flow around a sharp-edged delta wing with 65-deg sweep and a flat upper surface was investigated experimentally as well as numerically. The experimental program consisted of surface pressure measurements, oil flow visualization, and flow field explorations at Mach numbers 0.60 and 0.85 and angles of attack up to 20 deg. The results show a transonic leeward flow structure with several shock waves. At a Mach number of 0.85 and 20 deg angle of attack vortex breakdown is observed. The vortex breakdown goes along with a double shock system in the symmetry plane region. In the numerical program a 3D Euler code is used with two upwind schemes; one of the flux-splitting type and one of the flux-difference-splitting type. The results show significant differences between the two discretization schemes, in particular in the region of the vortex. Between computations and experiments large differences are observed due to the absence of secondary separation, and, at the higher angles of attack, due to the absence of vortex breakdown in the computations. Author

N92-13002*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
RECENT PROGRESS IN COMPUTATIONAL VORTEX-FLOW AERODYNAMICS
JAMES M. LUCKRING *In* AGARD, Vortex Flow Aerodynamics 21 p Jul. 1991
Copyright Avail: NTIS HC/MF A23; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive
CSCL 01/1

Recent progress in computational vortex flow aerodynamics at the Langley Research Center is reviewed. Emphasis is placed on Navier-Stokes methodology, both for compressible and incompressible flows, and results are presented from central and upwind-biased schemes for fully laminar, transitional, and fully turbulent flows. In addition, results are presented from selected potential-based methods to address the hierarchy of formulations presently available for the computational analysis of aerodynamic vortex flows. Some comparisons among this hierarchy of methods are shown. Author

N92-13003# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.).
ON THE SIMULATION OF COMPRESSIBLE TURBULENT FLOWS PAST DELTA WING, DELTA WING-BODY AND DELTA WING-CANARD
ACHIM HILGENSTOCK and HEINRICH VOLLMERS *In* AGARD, Vortex Flow Aerodynamics 13 p Jul. 1991
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The turbulent flow around a delta wing at incidence is simulated numerically using a finite volume Navier-Stokes method. The numerical simulation makes use of a simple algebraic turbulence model. Using a sharp leading edge delta wing, the influence of grid refinement is investigated. A realistic wing-body configuration with a round leading edge is used to discuss the influence of the position of the transition line. Experimental and numerical data are compared to validate the numerical method. The topological structure of the flow is discussed. An explanation is given for the low particle density area close to the primary vortex as it is visualized by the laser light sheet technique. First results for a closed coupled delta-wing-canard configuration are also discussed. Author

N92-13004# Aeronautical Research Inst. of Sweden, Bromma.
CALCULATION OF HYPERSONIC LEESIDE VORTICES OVER BLUNT DELTA WINGS
ARTHUR RIZZI, EARLL M. MURMAN, PETER ELIASSON, and KUOK-MING LEE (Massachusetts Inst. of Tech., Cambridge.) *In* AGARD, Vortex Flow Aerodynamics 17 p Jul. 1991
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Hypersonic vortical flow on the leeside of a blunt delta wing using both the Euler equations and the Navier-Stokes equations with two different and independent numerical methods in order to evaluate the inviscid and viscous mechanisms of leeside vortex formation is investigated. Comparisons of results from the same method as well as comparisons of results from the two different methods are the focal point of this work. The intent is to reach a reasonable understanding of the computed flow structures, including flow separation, shear layers, vortices, shock waves, and entropy losses. It was found that instead of the concentrated vortex usually found over a delta wing in transonic speed, the flow in hypersonic speed is dominated by a shear layer that separates just past the blunt leading edge and forms a more distributed vortical region over the wing. Windside features like the bow shock agree well in all the numerical solutions. But there are substantial discrepancies in the prediction of the Stanton number on the wing surface. Author

N92-13005# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.).
ON THE FOOTPRINTS OF THREE-DIMENSIONAL SEPARATED VORTEX FLOWS AROUND BLUNT BODIES: ATTEMPTS OF DEFINING AND ANALYZING COMPLEX FLOW STRUCTURES
UWE DALLMANN, ACHIM HILGENSTOCK, STEFAN RIEDELBAUCH, BURKHARD SCHULTE-WERNING, and HEINRICH VOLLMERS *In* AGARD, Vortex Flow Aerodynamics 13 p Jul. 1991
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An analysis of vortex flows around different configurations in very different Mach and Reynolds regimes is presented. Subsonic, transonic, and hypersonic separated flows are considered. The common interest was to study the relationships between the topologies of steady or unsteady, two dimensional or three dimensional separated vortex flow structures and their footprints which they leave on the boundaries (walls) or within any section across the flow field. From this point of view numerical Navier Stokes simulations are analyzed in the following respect: Topological changes of the instantaneous sectional streamlines and the skin friction patterns of incompressible flows are considered during vortex shedding and during onset of three dimensionality of the flow. Two dimensional separation bubbles, separation from

a cylinder in crossflow, and separation from a sphere are analyzed. The formation of vortex cores and their relationship to so called open or closed flow separation, wall vorticity, wall pressure, wall heat flux, and various sectional flow data are investigated in compressible flows such as the transonic transitional flow around a round edged delta wing and the hypersonic laminar flow around a double ellipsoid. Author

N92-13006# East Anglia Univ., Norwich (England). School of Mathematics.
LAMINAR-FLOW SECONDARY SEPARATION ON A SLENDER WING
K. KIRKKOPRU and N. RILEY *In* AGARD, Vortex Flow Aerodynamics 10 p Jul. 1991
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High Reynolds number laminar flow of an incompressible fluid past a slender delta wing at incidence is considered. An interactive viscous inviscid calculation is carried out to determine the secondary separation flow properties on the wing. The overall interactive procedure includes a modification to the leading edge vortex sheet configuration which represents the primary separation. Encouraging comparisons are made with experiment. Author

N92-13007*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NONEQUILIBRIUM TURBULENCE MODELING EFFECTS ON TRANSONIC VORTICAL FLOWS ABOUT DELTA WINGS
UNVER KAYNAK, EUGENE TU, MUSTAFA DINDAR, and REMZI BARLAS (Turkish Aerospace Industries, Ankara.) *In* AGARD, Vortex Flow Aerodynamics 13 p Jul. 1991 Sponsored in part by NASA
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The Johnson-King turbulence model that is a viable method for calculating two dimensional transonic separated flows was extended into three dimensions. The implementation was done for Navier Stokes flow solvers written in general curvilinear coordinates. The present approach used in turbulence modeling is based on streamwise integration of an ordinary differential equation (o.d.e.) that governs the maximum Reynolds shear stress behavior. Streamwise integration of the o.d.e. approach was found to offer great mathematical simplicity and economy for three dimensional Navier Stokes methods. Thus, the new method is quick, simple, and very cheap. The new method was first checked against the data of a well known transonic axisymmetric bump experiment, and a good agreement was obtained. Later, the new method was used to compute the flow around a low aspect ratio wing in a transonic wind tunnel. Finally it was employed to study the nonequilibrium turbulence effects on the transonic vortical flows about a 65 deg sweep round leading edge delta wing. Author

N92-13008# Royal Aircraft Establishment, Farnborough (England).
REVIEW OF AIRCRAFT DYNAMIC LOADS DUE TO FLOW SEPARATION
D. G. MABEY *In* AGARD, Vortex Flow Aerodynamics 10 p Jul. 1991
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A detailed review of the 70th meeting of the Advisory Group for Aerospace Research and Development (AGARD) Structures and Materials Panel, prepared for the AGARD Fluid Dynamics Panel, is presented. Accordingly emphasis is placed on the aerodynamic information presented, rather than the structural aspects. Experimental results and computations are described for flows with bubble and vortex separations. Some conclusions are drawn and recommendations are made for further research. In particular, the review suggests that much greater attention should be given to establishing the magnitude of possible scale effects (both in experiments and calculations) and to the prediction of fin buffeting. Author

N92-13009*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
IN-FLIGHT FLOW VISUALIZATION AND PRESSURE MEASUREMENTS AT LOW SPEEDS ON THE NASA F-18 HIGH ALPHA RESEARCH VEHICLE
JOHN H. DELFRATE, DAVID F. FISHER, and FANNY A. ZUNIGA *In* AGARD, Vortex Flow Aerodynamics 42 p Jul. 1991 Previously announced as N90-28505
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Inflight results from surface and off surface flow visualizations and from extensive pressure distributions document the vortical flow on the leading edge extensions (LEXs) and forebody of the NASA F-18 high alpha research vehicle (HARV) for low speeds and angles of attack up to 50 deg. Surface flow visualization data, obtained using the emitted fluid technique, were used to define separation lines and laminar separation bubbles (LSB). Off surface flow visualization data, obtained by smoke injection, were used to document both the path of the vortex cores and the location of vortex core breakdown. The location of vortex core breakdown correlated well with the loss of suction pressure on the LEX and with the flow visualization results from ground facilities. Surface flow separation lines on the LEX and forebody corresponded well with the end of pressure recovery under the vortical flows. Correlation of the pressures with wind tunnel results show fair to good correlation. Author

N92-13010# Technische Univ., Brunswick (Germany, F.R.).
VORTEX FORMATION OVER A CLOSE-COUPLED CANARD-WING-BODY CONFIGURATION IN UNSYMMETRICAL FLOW
A. BERGMANN, D. HUMMEL, and H.-CHR. OELKER (Dornier System G.m.b.H., Friedrichshafen, Germany, F.R.) *In* AGARD, Vortex Flow Aerodynamics 14 p Jul. 1991
(Contract DFG-HU-254/8)
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A close coupled canard wing body combination was investigated in unsymmetrical flow. The configuration consisted of a delta canard, a delta wing, and a body of revolution as the fuselage. Six component and surface pressure distribution measurements as well as flow visualizations by means of the laser lightsheet technique were carried out at Reynolds numbers (based on wing inner chord) of Re = 1.1 x 10(exp 6) and Re = 1.4 x 10(exp 6) for the canard-off and the canard-on configuration. For large angles of attack distinct jumps of the aerodynamic coefficients have been detected in unsymmetrical flow which are due to sudden changes of the flow structure. In the canard-off configuration they are caused by the collapse of the vortex type flow on the windward side of the configuration into a deadwater type flow which takes place when the vortex breakdown position within the wing vortices reaches the wing apex. In the canard-on configuration the sensitive and favorable interference between canard and wing is suddenly disturbed. Apart from a small region in the vicinity of the symmetrical flow in which a vortical flow at the canard can be maintained up to extremely large angles of attack, in unsymmetrical flow at high angles of attack the flow over the windward side of the canard collapses from a vortex type flow to a deadwater type flow due to a sudden loss of favorable interference, and this causes the jumps in the slope of the aerodynamic coefficients. Author

N92-13011# National Aerospace Lab., Amsterdam (Netherlands).
AN EXPERIMENTAL STUDY OF THE FLOW OVER A SHARP-EDGED DELTA WING AT SUBSONIC AND TRANSONIC SPEEDS
A. ELSENAAR and H. W. M. HOEIJMAKERS *In* AGARD, Vortex Flow Aerodynamics 19 p Jul. 1991 Sponsored in part by the Netherlands Agency for Aerospace Program (NIVR) for the

Netherlands Ministry of Defence
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The flow about a sharp edged cropped delta wing is investigated experimentally. The experiment comprised detailed surface pressure measurements at low subsonic, transonic, and low supersonic freestream Mach numbers for angles of attack up to 27 deg. The major part of the measurements were carried out at a Reynolds number of 9 million, but some data was also obtained at lower and higher Reynolds numbers. The investigation included continuous schlieren flow field visualization as well as surface flow visualizations at a limited number of free stream conditions. The analysis of the measured data embraced flow field phenomena such as primary separation and the formation of the leading edge vortex, secondary separation and the formation of the secondary vortex, shock waves, and the onset of vortex breakdown. Considered are the influence of Mach number, incidence, and Reynolds number on these flow features. Author

N92-13012# Office National d'Etudes et de Recherches Aerospatiales, Toulouse (France). Dept. d'Aerothermodynamique.
CHARACTERISTICS OF A BOUNDARY LAYER IN A LEADING EDGE VORTEX [CARACTERISTIQUES D'UNE COUCHE LIMITE EN AVAL D'UN TOURBILLON DE BORD D'ATTAQUE]
G. PAILHAS and J. COUSTEIX *In* AGARD, Vortex Flow Aerodynamics 17 p Jul. 1991 In FRENCH; ENGLISH summary
 Avail: NTIS HC/MF A23; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The boundary layer developing downstream of a leading edge vortex was investigated. This experiment is devoted to the understanding of the behavior of such a boundary layer submitted to the effects of a leading edge vortex developing on the suction side of a swept wing. The infinite swept wing considered for the present study is mounted between the top and the bottom walls of the test section at a sweep angle of 60 degrees and at an incidence of 15 degrees. The airfoil is symmetric and has a maximum thickness ratio of .1 and a chord length of 200 mm; it is an ONERA D airfoil, that is, a peaky-type airfoil. Mean and turbulent velocity profile surveys were carried out in various positions located downstream of the reattachment line, but also for a few positions in the vortex core by means of hot wire anemometry. Measurements in the vortex core and in the boundary layer were made by using respectively a four and single hot wire probe. Author

N92-13014# Royal Aircraft Establishment, Farnborough (England). Aerodynamics Dept.
ASYMMETRIC VORTEX FLOW OVER CIRCULAR CONES
M. PIDD and J. H. B. SMITH *In* AGARD, Vortex Flow Aerodynamics 11 p Jul. 1991
 Avail: NTIS HC/MF A23; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Presented here is an update on earlier Royal Aerospace Establishment (RAE) work on the formation of asymmetric vortices from slender pointed bodies at large angles of incidence. The emphasis is on theoretical and experimental work on flow over circular cones. For a single line vortex model of asymmetric conical flow over circular cones with symmetric separation lines, a thorough exploration of parameter space revealed only insignificant regions of multiple solutions and no further bifurcation locus from which asymmetric solutions could arise. An examination of the stability of solutions of this model to small spatial disturbances has shown that stable symmetric solutions are confined to a narrow band of values of the incidence parameter, but that, with insignificant exceptions, the asymmetric solutions are stable. An examination of low speed experimental data shows that asymmetric flow over a circular cone can be significantly non-conical with large variations in local side force coefficient along the length of the cone. At an angle of incidence of 35 degrees on a 10 degree cone, the approximately conical flows appear to predominate, but at 30 degrees they only occur exceptionally. Author

N92-13015# Royal Aircraft Establishment, Farnborough (England). Aerodynamics Dept.
AN EXPERIMENTAL INVESTIGATION OF THE EFFECT OF FINENESS RATIO ON LATERAL FORCE ON A POINTED SLENDER BODY OF REVOLUTION
I. R. M. MOIR *In* AGARD, Vortex Flow Aerodynamics 13 p Jul. 1991
 Avail: NTIS HC/MF A23; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Tests were made on a slender body model in the Royal Aerospace Establishment (RAE) Farnborough 5 meter pressurized low speed wind tunnel. Measurements of side force variation with angle of incidence and with roll angle are presented, together with an examination of the angle of incidence at which side force onset occurs and how this varies with nose apex angle, overall fineness ratio, and Reynolds number. A flow visualization technique was used to study the development of vortical symmetry as angle of incidence was increased. Author

N92-13016# Office National d'Etudes et de Recherches Aeronautiques, Paris (France).
PHYSICS OF VORTICAL FLOW [PHYSIQUE DES ECOULEMENTS TOURBILLONNAIRES]
J. DELERY *In* AGARD, Vortex Flow Aerodynamics 32 p Jul. 1991 In FRENCH, ENGLISH summary
 Avail: NTIS HC/MF A23; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

In three dimensional flows, separation leads to the formation of vortical structures resulting from the rolling up of a sheet of viscous flow, initially contained in a thin boundary layer, which springs out from the obstacle surface into the outer perfect fluid flow. A clear physical understanding of this phenomenon must rely on a rational analysis of the flowfield, calling upon the critical points theory. With this theory, it is possible to correctly interpret the surface flow patterns which constitute the imprints of the outer flow and to give a rational description of the vortical system. This kind of analysis is applied to separated flows generated by typical bodies, the field of which has been carefully investigated by means of visualizations and surveys using multi-hole probes and laser velocimetry. The problem of vortex breakdown, so important for a large number of applications, is discussed briefly. Author

N92-13017*# Notre Dame Univ., IN. Dept. of Aerospace and Mechanical Engineering.
BREAKING DOWN THE DELTA WING VORTEX: THE ROLE OF VORTICITY IN THE BREAKDOWN PROCESS
R. C. NELSON and KENNETH DALE VISSER *In* AGARD, Vortex Flow Aerodynamics 15 p Jul. 1991 Sponsored in part by Notre Dame Univ.
(Contract NAG1-1156)
 Avail: NTIS HC/MF A23; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive CSCL 01/1

Experimental x-wire measurements of the flowfield above a 70 degree and 75 degree flat plate delta wing were performed at a Reynolds number of 250,000. Grids were taken normal to the wing at various chordwise locations for angles of attack of 20 degrees and 30 degrees. Axial and azimuthal vorticity distributions were derived from the velocity fields. The dependence of circulation on distance from the vortex core and on chordwise location was also examined. The effects of nondimensionalization in comparison with other experimental data is made. The results indicate that the circulation distribution scales with the local semispan and grows in a nearly linear fashion in the chordwise direction. The spanwise distribution of axial vorticity is severely altered through the breakdown region and the amount of vorticity present appears to reach a maximum immediately preceding breakdown. The axial velocity components with a negative sense, such as that found in the secondary vortex, seem to remain unaffected by changes in wing sweep or angle of attack, in direct contrast to the visible components. In addition, the inclusion of the local wing geometry into a previously derived correlation parameter allows the circulation

of growing leading edge vortex flows to be reduced to a single curve. Author

N92-13018# Office National d'Etudes et de Recherches Aeronautiques, Paris (France).
DETERMINATION OF VORTEX-BREAKDOWN CRITERIA BY SOLVING THE EULER AND NAVIER-STOKES EQUATIONS [DETERMINATION DE CRITERES D'ECLATEMENT TOURBILLONNAIRE PAR RESOLUTION DES EQUATIONS D'EULER ET DE NAVIER STOKES]
T. H. LE, PH. MEGE, and Y. MORCHOISNE *In* AGARD, Vortex Flow Aerodynamics 10 p Jul. 1991 In FRENCH; ENGLISH summary Previously announced in IAA as A91-26081
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A parametric study based on numerical simulations which solve Euler and Navier-Stokes equations is performed on the configuration of an isolated vortex subjected to an initial perturbation. An analysis of the vortex breakdown characteristics indicates that the phenomenon appears abruptly, that it is three dimensional and unsteady by nature, and that the turbulence is characterized by small-scale structures that are established at a specified moment. This analysis permits a criterion to be specified that is based on an appropriately defined local Rossby number to determine the area where breakdown occurs. Author

N92-13019*# McDonnell Aircraft Co., Saint Louis, MO. Aerodynamics Dept.
INVESTIGATION OF VORTEX BREAKDOWN ON A DELTA WING USING EULER AND NAVIER-STOKES EQUATIONS
S. AGRAWAL, R. M. BARNETT, and B. A. ROBINSON *In* AGARD, Vortex Flow Aerodynamics 12 p Jul. 1991
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A numerical investigation of leading edge vortex breakdown in a delta wing at high angles of attack is presented. The analysis was restricted to low speed flows on a flat plate wing with sharp leading edges. Both Euler and Navier-Stokes equations were used and the results were compared with experimental data. Predictions of vortex breakdown progression with angle of attack with both Euler and Navier-Stokes equations are shown to be consistent with the experimental data. However, the Navier-Stokes predictions show significant improvements in breakdown location at angles of attack where the vortex breakdown approaches the wing apex. The predicted trajectories of the primary vortex are in very good agreement with the test data, the laminar solutions providing the overall best comparison. The Euler shows a small displacement of the primary vortex, relative to experiment, due to the lack of secondary vortices. The turbulent Navier-Stokes, in general, fall between the Euler and laminar solutions. Author

N92-13020*# Vigyan Research Associates, Inc., Hampton, VA.
VORTEX CONTROL: FURTHER ENCOUNTERS
DHANVADA M. RAO *In* AGARD, Vortex Flow Aerodynamics 12 p Jul. 1991 Sponsored in part by NASA. Langley Research Center; and by AF
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The progress of continuing investigations on vortex control techniques is updated. The following topics are briefly discussed: (1) vortex flaps adapted for high-alpha control; (2) alleviation of leading edge extension (LEX) vortex induced twin-tail buffet; (3) controlled decoupling of interactive forebody chine and wing vortices; (4) forebody vortex manipulation by mechanical and pneumatic techniques; and (5) stall-departure alleviation of high aspect-ratio wings. Salient results of exploratory low speed wind tunned experiments are presented. The investigations, primarily aimed at concept validation, were performed on generic configurations utilizing flow visualizations and pressure and balance measurements. Selected results illustrate the efficacy and potential for development of specific vortex control concepts for improved high-alpha configuration aerodynamics. Author

N92-13021# Technische Univ., Aachen (Germany, F.R.). Dept. of Aerospace Engineering.
ON AIRCRAFT WAKE PROPERTIES AND SOME METHODS FOR STIMULATING DECAY AND BREAKDOWN OF TIP VORTICES
R. STAUFENBIEL and T. VITTING *In* AGARD, Vortex Flow Aerodynamics 14 p Jul. 1991 Sponsored in part by Deutsche Forschungsgemeinschaft (DFG)
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Investigations on the formation and structure of wing tip vortices are presented. A computational method for the time-dependent roll-up process is derived, which is based on the Biot-Savart approach with a particular technique of amalgamation which preserves energy, center of vorticity, and the second moment of vorticity distribution. The results are compared with laser Doppler velocimeter (LDV) measurements performed in a water tunnel. The influence of lift distribution on maximum circumferential velocity of trailing vortices is investigated. Moreover, some special devices for vortex wake alleviation were experimentally investigated in order to reveal the potential of three methods for vortex wake alleviation: (1) artificially destabilizing the vortex; (2) inducing breakdown of the vortex core; and (3) spreading and splitting the vorticity of trailing vortices. Author

N92-13022# Royal Aircraft Establishment, Farnborough (England). Aerodynamics Dept.
CONTROL OF FOREBODY VORTICES BY SUCTION AT THE NOSE OF THE RAE HIGH INCIDENCE RESEARCH MODEL
A. JEAN ROSS and E. B. JEFFERIES *In* AGARD, Vortex Flow Aerodynamics 9 p Jul. 1991
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The concept of applying suction at the nose of forebodies at high angle of attack to control the vortex flow was applied in static and dynamic wind tunnel tests on the RAE High Incidence Research Model. The first series of static tests showed that sideforce and yawing moment varied nearly linearly with the flow rate (or mass flow) coefficient, rather than the momentum coefficient, up to a maximum, but the maximum control powers available were small on the original drooped forebody. The results for suction on a large ogival forebody give yawing moment equivalent to about 25 degrees of rudder at an angle of attack of 30 degrees, and significantly higher for higher angles. They also show some dependence on whether separation is laminar or turbulent, and parameters defining the variation with flow rates are compared. Dynamic experiments on a free-to-yaw rig, with active control of flow rates, were inconclusive and further experiments are being conducted. Author

N92-13023# Royal Aircraft Establishment, Farnborough (England).
AN EXPERIMENTAL INVESTIGATION OF VORTEX FLAPS ON A CANARD COMBAT-AIRCRAFT CONFIGURATION
D. A. LOVELL *In* AGARD, Vortex Flow Aerodynamics 11 p Jul. 1991
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A low-speed wind tunnel investigation of two vortex-flap configurations fitted to a canard-delta combat-aircraft research model having a 53 degree sweep wing is reported. The effect of foreplane interference and vortex-flap geometry on the aerodynamic performance of the vortex flaps is determined. It is concluded that vortex flaps can generate large gains in trimmed lift and lift to drag ratio, particularly when used in conjunction with trailing-edge flaps. Author

N92-13024# General Dynamics Corp., Fort Worth, TX.
STEADY AND UNSTEADY AERODYNAMICS OF A PITCHING STRAKED WING MODEL AT HIGH ANGLES OF ATTACK

A. M. CUNNINGHAM, JR. and R. G. DENBOER (National Aerospace Lab., Amsterdam, Netherlands) *In* AGARD, Vortex Flow Aerodynamics 10 p Jul. 1991

Results are presented and discussed for the low speed test of a straked wing model oscillating in pitch that was conducted during 1986 at the National Aerospace Laboratory of the Netherlands. The model was oscillated about mean angles of attack ranging from -4 to 48 degrees with amplitudes varying from 2 to 18 degrees for a maximum incidence range of -8 to 50 degrees. It was also oscillated in pitch at side slip angles of 5 and -5 degrees. Force, pressure, and flow visualization data were recorded, processed, and documented in log magnetic tapes. A description of the model, test programs, steady aerodynamic characteristics, and unsteady aerodynamic characteristics is presented. These results are used to provide a better understanding of the unsteady forces experienced by rapidly pitching wings at low speed conditions ranging from zero incidence to fully stalled flows. Dynamic rolling moments for the pitching model at steady side-slip are also discussed to illustrate asymmetric aerodynamic hysteresis effects. Finally, implications for aircraft flight dynamics modeling are discussed with particular emphasis on nonlinear time dependency effects. Author

N92-13025# National Research Council of Canada, Ottawa (Ontario). Inst. for Aerospace Research.

SOME CHARACTERISTICS AND EFFECTS OF THE F/A-18 LEX VORTICES

D. BROWN, B. H. K. LEE, and F. C. TANG *In* AGARD, Vortex Flow Aerodynamics 20 p Jul. 1991

The first phase of a wind tunnel program to measure mean and unsteady forces and moments and pressure distributions on the forward fuselage, leading-edge extension (LEX), fins and in the LEX vortex wake of a 6 percent rigid model of the F/A-18 aircraft was accomplished. The effect of compressibility up to Mach 0.8 was studied. The mean chord Reynolds number range was 1.2 to 3.8 x 10(exp 6). Mean pressures were measured at 84 orifices distributed between canopy, forward fuselage, and the LEX. Unsteady and mean pressure measurements were made at four points on the LEX and at 24 points on each side of the fin. The vortex wake measurements were made with a 49 tube total pressure rake of which 13 tubes were capable of acquiring unsteady as well as mean pressures. The effects of the LEX fences, that were retroactively fitted to CF-18 aircraft in service, were assessed. The influence on aircraft lift and pitching moments is small. The data shows their local effect on LEX pressures, reduction in fin mean and unsteady loading that they cause, and their effect on the stagnation pressure distribution in the vortex wake. Author

N92-13026# National Aeronautical Establishment, Ottawa (Ontario). Inst. for Aerospace Research.

MULTIPLE ROLL ATTRACTORS OF A DELTA WING AT HIGH INCIDENCE

E. S. HANFF and L. E. ERICSSON (Lockheed Missiles and Space Co., Sunnyvale, CA.) *In* AGARD, Vortex Flow Aerodynamics 10 p Jul. 1991

A comprehensive roll oscillation test program on a 65 degree delta wing was conducted at the IAR (formerly NAE) 2 x 3 m low speed wind tunnel. The principle objectives of the program were to obtain a better insight of the vortex dynamics associated with large-amplitude and high-rate roll oscillations and to validate the hypersurface representation of aerodynamic loads as a means of improving prediction of aircraft dynamics in the nonlinear regime. Although some of the observed unusual roll response characteristics can be qualitatively explained in terms of existing knowledge regarding unsteady aerodynamic effects of separated flow, further tests and data analyses will be needed to reach the in-depth understanding of the flow phenomena which is required for the successful design of future high-agility aircraft. Author

N92-13027# Technical Univ. of Istanbul (Turkey). Faculty of Aeronautics and Astronautics.

NUMERICAL SIMULATION OF VORTEX STREET-EDGE INTERACTION

M. O. KAYA, C. R. KAYKAYOGLU, K. C. BAYAR, and J. M. R. GRAHAM (Imperial Coll. of Science and Technology, London, England) *In* AGARD, Vortex Flow Aerodynamics 12 p Jul. 1991

Preliminary results and computational method reviews are presented for the simulation of a vortex street impinging on three different leading edge geometries of sharp, blunt, and elliptic type, making use of Lagrangian and mixed Lagrangian-Eulerian vortex methods. Two new computer codes were developed to capture the essential features of the interaction mechanism near the edge surface. The first method utilizes a Discrete Vorticity Method (DVM) where a fixed Eulerian mesh system is needed to move the vortices through the flow domain. A more advanced computer model of the full Navier-Stokes equations of motion combines the Lagrangian convection and Eulerian diffusion schemes and is called the Hybrid Moving Vortex Diffusive Method (HMVDM). An unsteady shear layer flow arising from boundary layer separation at a bluff trailing edge creates the downstream vortex street. The models simulate most features of the impingement including the secondary vortex shedding as a truly self-generated phenomenon arising from impingement of the large-scale incident disturbances. The approaching vortex street is effected by the diverging flow around the elliptic edge. Vortex impingement on a blunt edge causes the most complex features of the interaction. The unsteady pressure distributions agree with the common observations. Author

N92-13028# Politecnico di Milano (Italy). Dipt. di Ingegneria Aerospaziale.

NUMERICAL SIMULATION OF VORTEX FLOWS PAST IMPULSIVELY STARTED WINGS

A. BARON, M. BOFFADOSSI, and S. DEPONTE *In* AGARD, Vortex Flow Aerodynamics 14 p Jul. 1991

A nonlinear unsteady vortex lattice method is used to predict the geometry of the wakes and the distribution of the aerodynamic loads on impulsively started wings. The wings are assumed to have negligible thickness, arbitrary aspect ratio, and planform. They can undergo a general unsteady motion. Multi-wing configurations can be treated. Wakes can be released in the flowfield from any of the sharp edges of the lifting surfaces, depending on planform, aspect ratio, and attitude of the wings. Particular emphasis is placed on the simulation of vortex core diffusion which is regarded as a prominent factor in a correct development of unsteady wakes. A vortex core diffusion model is proposed which seems to be able to deal even with the severe roll-up of the shear layers past highly swept multi-wing configurations with leading edge separation. The prediction capabilities of the method are verified by comparison of the numerical results with experimental data published by various authors. Author

N92-13029 North Carolina State Univ., Raleigh.

NUMERICAL INVESTIGATION OF UNSTEADY SUPERSONIC CAVITY FLOWFIELD WITH PASSIVE CONTROL Ph.D. Thesis

INSUN KIM 1991 101 p

Avail: Univ. Microfilms Order No. DA9122008 CSCL 01/1

A computational investigation of the supersonic turbulent flow over a two-dimensional rectangular cavity with passive control was conducted. The effect of passive control was included through the use of a porous surface over a vent chamber in the floor of the cavity. The passive control was numerically simulated by the use of a linear form of the Darcy pressure-velocity law. The time-accurate solutions of the two-dimensional Reynolds-averaged Navier-Stokes equations were generated using the explicit

MacCormack scheme. The capability of the numerical scheme was first demonstrated by the computations of an open and closed cavity flow without passive control. The results of these computations also provided a reference case for the passive control computations. The effect of passive control on the open and closed cavity flows was then demonstrated and analyzed. The numerical results of open cavity flow with passive control suggested that the passive control effectively suppresses the pressure oscillations associated with the open cavity flow. Spectral analysis of the unsteady solution of open cavity flow showed that the cavity resonant frequencies are only slightly changed by the passive control and that the resonant frequencies of the cavity flow without passive control agree favorably with the predictions of the modified Rossiter's semi-empirical formula. The fluid dynamic mechanism of the control was seen to be a stabilization of the free-shear layer. Beneficial reductions in the cavity drag were also observed. Passive control applied to the closed cavity flow modified the flowfield to nearly that of an open cavity flow. The free-shear layer was seen to bridge the cavity completely. Drag reduction by a factor of 4 was achieved. The computational results showed good agreement with the available experimental data.

Dissert. Abstr.

N92-13030 Toledo Univ., OH.
EFFECTS OF INLET DISTORTION ON THE DEVELOPMENT OF SECONDARY FLOWS IN A SUBSONIC AXIAL INLET COMPRESSOR ROTOR Ph.D. Thesis
ALBERT KARL OWEN 1991 340 p
Avail: Univ. Microfilms Order No. DA9122424

Detailed flow measurements were taken inside an isolated axial compressor rotor operating subsonically near peak efficiency. Laser anemometer measurements were made with two inlet velocity profiles. One profile consisted of an unmodified baseline flow, and the second profile was distorted by placing axisymmetric screens on the hub and shroud well upstream of the rotor. A primary flow is defined in the rotor, and deviations from this primary flow for each inlet flow condition are identified. A comparison between the two flow deviations is made to assess the development of a passage vortex due to the distortion of the inlet flow. A comparison of experimental results with computational predictions from a Navier-Stokes solver showed good agreement between predicted and measured flows. Measured results indicate that a distorted inlet profile has a minimal effect on the development of the flow in the rotor passage and the resulting passage vortex.

Dissert. Abstr.

N92-13031 Notre Dame Univ., IN.
AN EXPERIMENTAL ANALYSIS OF CRITICAL FACTORS INVOLVED IN THE BREAKDOWN PROCESS OF LEADING EDGE VORTEX FLOWS Ph.D. Thesis
KENNETH DALE VISSER 1991 285 p
Avail: Univ. Microfilms Order No. DA9122937

Experimental crosswire measurements of the flowfield above a 70 and 75 degree flat plate delta wing were performed at a Reynolds number of 250,000. Survey grids were taken normal to the planform at a series of chordwise locations for angles of attack of 20 and 30 degrees. Axial and azimuthal vorticity distributions were derived from the velocity fields. The dependence of circulation on distance from the vortex core as well as on chordwise location was examined. The effects of nondimensionalization in comparison with other experimental data was made. A reduction in the local circulation about the vortex axis occurred at breakdown. The spanwise distribution of axial vorticity was severely altered through the breakdown region and the spanwise distribution of axial vorticity present appeared to reach a maximum immediately preceding breakdown. The local concentration of axial vorticity about the vortex axis was reduced while the magnitude of the azimuthal vorticity decreased throughout the breakdown zone. The axial vorticity components unaffected by changes in wing sweep or angle of attack, in direct contrast to the positive components. The inclusion of the local wing geometry into a previously derived correlation parameter indicated the circulation of growing leading edge vortex flows to be similar at corresponding radii from the vortex axis. It was concluded that the flow over a delta wing, upstream of the breakdown regions and away from the apex and trailing edge regions, is conical. In addition, the dominating factors leading to the onset of breakdown are felt to be the local circulation of the vortex and the accompanying pressure field.

Dissert. Abstr.

N92-13032 Virginia Polytechnic Inst. and State Univ., Blacksburg.
OSCILLATING SHOCK IMPINGEMENT ON LOW-ANGLE GAS INJECTION INTO A SUPERSONIC FLOW Ph.D. Thesis
CHARLES WADE WOOD 1991 191 p
Avail: Univ. Microfilms Order No. DA9123765

Experiments were performed to determine the effects of impinging oscillating shocks of different frequencies on a 115 deg. downstream angled, underexpanded, sonic helium jet injected into a supersonic airflow. Information on mixing, penetration, total pressure loss and turbulence structure from these experiments was used to estimate mixing control achieved by adding an oscillating shock to the helium injection flow field. The primary measurement made for the mixing studies was the molar concentration of helium. Concentration data, as well as mean flow data, was collected at nine lateral positions at each of three axial stations downstream of the helium injector. The resulting data produced contours of helium concentration, total pressure, Mach number, velocity, mass flux and static flow properties. Additional tests were conducted to determine the shock oscillation frequency, the correlation between the oscillating shock and the turbulence in the shear layer and the angle of large-scale structures in the flow. Mixing and penetration rates were determined from the helium concentration data. The major result was that impingement of an oscillating shock on a high-speed shear layer can be used to control the rate of mixing. It was found that increasing shock oscillation frequency resulted in more rapid injectant concentration decay and increased freestream air entrainment leading to a stoichiometric H2-air mixture ratio while also reducing penetration of the helium injectant. A strong correlation was found between the highest frequency shock and changes in the mixing flow field.

Dissert. Abstr.

N92-13034# Naval Postgraduate School, Monterey, CA.
A STUDY OF THE AIRWAKE AERODYNAMICS OVER THE FLIGHT DECK OF AN AOR MODEL SHIP M.S. Thesis
MARK M. RHOADES Sep. 1990 102 p
(AD-A241008) Avail: NTIS HC/MF A06 CSCL 20/4

This study investigated the airwake of an AOR Class model ship to provide basic flow pattern and velocity information to aid in solving the elusive problem of blade strikes experienced by H-46 helicopters when they engage or disengage rotors aboard AOR ships. This investigation used the NPS flow visualization tunnel modified to simulate the atmospheric boundary layer. A detailed visualization was completed of the airflow near the flight deck area of a four-foot model in a stationary mode, utilizing helium bubbles, smoke, photographic and video equipment. The results show that the airwake is usually made up of two regions, one that is relatively smooth and one that is extremely turbulent. The dividing line is a shear layer that is created from the air flowing around the port face of the hangar. Another feature found both in the flow visualization, as well as the velocity measurements, was the presence of a significant upward component of flow over the port edge of the flight deck. It was found that this flow had nearly the same speed as the velocity measured at the ship's anemometer position but was inclined at an angle of between 15 and 25 degs. This upward flow, combined with the highly variable recirculations over the flight deck could be a significant contributing factor in the occurrence of blade strikes. In addition, some attempts were made to eliminate some of the more unruly flow patterns by using curved deflectors. These attempts had some success but will require further study. GRA

N92-13035# Naval Postgraduate School, Monterey, CA.
AERODYNAMIC COEFFICIENTS OF A SYMMETRICAL

AIRFOIL IN AN OSCILLATING FLOW M.S. Thesis
GEORGE A. CHAMBERLAIN, JR. Sep. 1990 102 p
(AD-A241073) Avail: NTIS HC/MF A06 CSCL 01/1

A symmetrical airfoil at fixed angle of attack from 0 to 35 degrees was placed in an air flow with controlled velocity oscillations at 10 Hz. The instantaneous pressure distribution and flow velocity were measured simultaneously. Pressure information was integrated numerically to determine instantaneous values for lift, drag and moment about the quarter chord. The results were plotted as three-dimensional surface plots in angle of attack, cycle time and performance coefficient axes, or with chordwise position, cycle time and pressure coefficient axes, as appropriate. The pressure distribution over the airfoil was shown to be primarily a function of freestream static pressure. Aerodynamic coefficients as a function of angle of attack and time exhibited seemingly random, erratic behavior, whereas the mean values of the same coefficients were similar in nature to those obtained in steady flow. The data indicate that the instantaneous performance of an airfoil in an oscillating flow is not merely a continuum of many quasi-steady states. GRA

N92-13036 Department of the Navy, Washington, DC.
STABILIZED SQUARE PARACHUTE Patent
CARL T. CALIANNO, inventor (to Navy) 6 Aug. 1991 6 p
Filed 18 Apr. 1990
(AD-D015014; US-PATENT-5,037,042;
US-PATENT-APPL-SN-518619; US-PATENT-CLASS-244-145)
Avail: US Patent and Trademark Office CSCL 01/3

This patent discloses a low cost square shaped parachute with trapezoidal panels attached to its canopy sides for controlling the air flow during operation to maximize drag and stability. GRA

N92-13037# Naval Postgraduate School, Monterey, CA.
WATER TUNNEL FLOW VISUALIZATION STUDIES OF A CANARD-CONFIGURED X-31A-LIKE FIGHTER AIRCRAFT MODEL M.S. Thesis
HUI M. KWON Sep. 1990 118 p
(AD-A241362) Avail: NTIS HC/MF A06 CSCL 01/3

A water tunnel flow visualization investigation was performed to study the vortex bursting phenomena on a 2.3 percent scale model of a X-31A-like fighter aircraft. The main focus of this study was two-fold: (1) to determine the optimum canard location that produces favorable aerodynamic interference on the main wing, and (2) to determine the effect of pitch rate on the optimum-configured model during simple pitch-up and simple pitch-down maneuvers. It was found that a close-coupled canard configuration resulted in a more favorable interference between the vortex systems of the canard and the wing. The dynamic tests indicated that the location of the wing root vortex burst point relative to the static case moved downstream with increasing pitch rate. GRA

N92-13038*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EFFECT OF SOLIDITY AND INCLINATION ON PROPELLER-NACELLE FORCE COEFFICIENTS
GARL L. GENTRY, JR., DANA MORRIS DUNHAM, and M. A. TAKALLU (Lockheed Engineering and Sciences Co., Hampton, VA.) Washington Dec. 1991 23 p
(NASA-TM-4316; L-16933; NAS 1.15:4316) Avail: NTIS HC/MF A03 CSCL 01/1

A series of wind tunnel experiments were conducted to study the effect of propeller solidity and thrust axis inclination on the propeller normal force coefficient. Experiments were conducted in the Langley 14 by 22 foot Subsonic Tunnel with a sting mounted, counterrotation, scale model propeller and nacelle. Configurations had two rows of blades with combinations of 4 and 8 blades per hub. The solidity was varied by changing the number of blades on both rows. Tests were conducted for blade pitch setting of 31.34 deg, 36.34 deg, and 41.34 deg over a range of angle of attack from -10 deg to 90 deg and range of advance ratio from 0.8 to 1.4. The increase in propeller normal force with angle of attack is greater for propellers with higher solidity. Author

N92-13838*# Valparaiso Univ., IN. Dept. of Mechanical Engineering.
EXPERIENCES WITH OPTIMIZING AIRFOIL SHAPES FOR MAXIMUM LIFT OVER DRAG
MICHAEL L. DORIA *In* Old Dominion Univ., NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1991 p 98-99 Sep. 1991
Avail: NTIS HC/MF A12 CSCL 01/1

The goal was to find airfoil shapes which maximize the ratio of lift over drag for given flow conditions. For a fixed Mach number, Reynolds number, and angle of attack, the lift and drag depend only on the airfoil shape. This then becomes a problem in optimization: find the shape which leads to a maximum value of lift over drag. The optimization was carried out using a self contained computer code for finding the minimum of a function subject to constraints. To find the lift and drag for each airfoil shape, a flow solution has to be obtained. This was done using a two dimensional Navier-Stokes code. Author

N92-13848*# Rice Univ., Houston, TX. Dept. of Mechanical Engineering and Materials Science.
THE USE OF ARTIFICIAL NEURAL NETWORKS IN EXPERIMENTAL DATA ACQUISITION AND AERODYNAMIC DESIGN
ANDREW J. MEADE, JR. *In* Old Dominion Univ., NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1991 p 142-145 Sep. 1991
Avail: NTIS HC/MF A12 CSCL 01/1

It is proposed that an artificial neural network be used to construct an intelligent data acquisition system. The artificial neural networks (ANN) model has a potential for replacing traditional procedures as well as for use in computational fluid dynamics validation. Potential advantages of the ANN model are listed. As a proof of concept, the author modeled a NACA 0012 airfoil at specific conditions, using the neural network simulator NETS, developed by James Baffes of the NASA Johnson Space Center. The neural network predictions were compared to the actual data. It is concluded that artificial neural networks can provide an elegant and valuable class of mathematical tools for data analysis. Author

N92-13849*# Wichita State Univ., KS. Dept. of Aerospace Engineering.
AN EVALUATION OF PRELIMINARY DOPPLER GLOBAL VELOCIMETRY MEASUREMENTS
L. SCOTT MILLER *In* Old Dominion Univ., NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1991 p 146-149 Sep. 1991
Avail: NTIS HC/MF A12 CSCL 01/1

A review of Doppler Global Velocimetry (DGV) data obtained during wind tunnel tests on a 75 degree swept delta wing was performed. High frequency variations observed in normalized data files are attributed to image alignment problems. Unfortunately, initial DGV velocity data compared poorly with baseline reference data. Nonlinear DGV system operation during the tests is the likely source of this problem. Corrected data compares much more favorably and suggests that DGV is a valid measurement technique. Future DGV investigations should include a method or means for monitoring laser frequency relative to the ALF transfer function behavior. Author

N92-13861*# Syracuse Univ., NY. Dept. of Mechanical and Aerospace Engineering.
CONSTANT-TEMPERATURE ANEMOMETRY MEASUREMENTS IN HYPERSONIC BOUNDARY LAYERS
ERIC F. SPINA *In* Old Dominion Univ., NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1991 p 210-212 Sep. 1991
Avail: NTIS HC/MF A12 CSCL 01/1

One of the major unresolved issues in fluid dynamics is the nature of apparent stresses, called Reynolds stresses, which occur in turbulent boundary layers. In hypersonic boundary layers, the flow physics is further complicated by the large temperature and

density fluctuations and the concomitant contamination of the Reynold stresses by fictitious terms. Because of the severe flow environment and the extraordinary demands on sensors and instruments, the turbulence characteristics of hypersonic boundary layers were studied in only a cursory fashion. The plans for supersonic (HSCT) and hypersonic (NASP) vehicles made supersonic flow physics one of the critical pacing technologies in aerospace science. In particular, experimental data are needed to verify candidate computer models and to reach an important understanding of the turbulence physics. The presented research is the start of a substantial effort to refine existing instrumentation and develop experimental techniques to measure the various component of the Reynolds stress in hypersonic boundary layers. Author

N92-13868*# California State Univ., Los Angeles. Dept. of Mechanical Engineering.
NAVIER-STOKES CALCULATION OF TRANSONIC FLOW PAST THE NTF 65 DEG DELTA WING
CHIVEY C. WU *In* Old Dominion Univ., NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1991 p 236-247 Sep. 1991
Avail: NTIS HC/MF A12 CSCL 01/1

Models of four delta wings were built and tested in the 8 x 8 ft Transonic Wind Tunnel at LaRC. The wings are identical in planform shape with a swept-back angle of 65 degrees, but bear different leading edge profiles. The models were tested under pressurized and cryogenic conditions to simulate true flight Reynolds numbers. Data on the aerodynamic forces and pressure distributions at various locations on the wings were taken at various flight Mach numbers and angles of attack. Effects of high Reynolds number and leading edge radius on the aerodynamic characteristics of the wings are being accessed. To thoroughly understand the turbulent, vortical flow around the wings, an effort to perform computational aerodynamic analysis is being made. The objective of the analysis is to supplement and validate the experimental data and explain the high Reynolds number and leading edge effects. GRIDGEN, a software developed by General Dynamics, is being used to generate the grid topology for the flow field around the wings. The flow solver to be used is CFL3D, a computation fluid dynamics code developed at LaRC. Based on the geometric description of the wings, a FORTRAN program called WINGSURF was written to generate the databases defining the surface geometry of the wings. To match the true geometry of the models in the wind tunnel for realistic comparison with experimental results, databases defining the sting support for the wing models were also created by two other FORTRAN programs, STINJOIN and STINREAR. Listing of the programs are attached and the geometry of a typical wing model with the sting support is shown. Other aspects of the investigation are discussed. Author

03

AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

A92-13700
MIND THAT RESTYLE
Aerospace (UK) (ISSN 0305-0831), vol. 18, Nov. 1991, p. 15-17.
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An analysis of the two sequential structural failures that occurred to the same composite rudder of a Concorde aircraft is described. In addition to showing evidence of having sustained overload in failing, the adhesive surfaces showed signs that the bonding failures, like the metal skin failures, had progressed from the aft end forward. Tests have shown that the use of paintstripper and the wrong adhesive applied to the composite material of the rudder were primarily responsible for the failures. R.E.P.

A92-14048
RATES AND RISK FACTORS FOR ACCIDENTS AND INCIDENTS VERSUS VIOLATIONS FOR U.S. AIRMEN
MAXINE E. LUBNER, JEFFREY S. MARKOWITZ, and DAVID A. ISHERWOOD (Columbia University, New York) International Journal of Aviation Psychology (ISSN 1050-8414), vol. 1, no. 3, 1991, p. 231-243. Research sponsored by FAA. refs
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Rates and risks of general aviation accidents/incidents and violations were calculated employing case-control methodology. Cases, selected from Federal Aviation Administration (FAA) records of currently active airmen who had one or more accidents, incidents, or violations during 1982-1987, totaled 11,548. A comparison of cases and controls was made by using five predictors: gender, age, medical certificate, airmen's certificate, and FAA region. All variables showed significant results as risks for, or as protective factors against, having an accident/incident or violation. Some variables showed a greater risk for violations than for accidents/incidents. The period prevalance, or the number of existing cases divided by the average population, was 12.7 per 1000 for accidents/incidents and 7 per 1000 for violations. It was recommended that accidents/incidents and violations should not be routinely aggregated because their epidemiology differs. Author

A92-14388
STAGE 2 NOISE CERTIFICATION OF THE SIKORSKY S-76A AND S-76C HELICOPTERS
ERIC W. JACOBS, RONALD D. PRILLWITZ, JAMES R. JOHNSON, and CHARLES A. YOERKIE, JR. (Sikorsky Aircraft, Stratford, CT) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 829-840.
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Stage 2 noise certification tests have been performed by Sikorsky Aircraft for the S-76A and S-76C helicopters. The S-76A test was the first to be conducted under the Noise Standards for Helicopters in the Normal, Transport, and Restricted Categories: Final Rule (14 CFR Parts 21 and 36) issued by the Federal Aviation Administration (FAA) in the Federal Register (Vol. 53, No.24) on February 5, 1988. This paper summarizes the methods used to conduct the noise certification flight tests, the analyses performed to determine take off, approach, and flyover effective perceived noise levels (EPNL) in accordance with Federal Aviation Regulation (FAR) Part 36, and some of the lessons learned during the S-76A and S-76C noise certification test programs. Author

A92-14454
AN ANALYTICAL STUDY OF THE HELICOPTER FLIGHT SAFETY UNDER AN ENGINE FAILURE IN PROXIMITY OF GROUND
VIKTOR B. LETNIKOV AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Paper. 19 p.

Analytical methods are presented for the safety evaluation of the helicopter flight in the case of either total or partial power plant failure. The methods proposed here can be used to solve a wide range of trajectory problems as part of a search for a rational piloting technique. The methods are illustrated by results of parametric studies for the MI-38 helicopter. V.L.

A92-14688
LIGHTNING STANDARDS FOR AIRCRAFT PROTECTION
ANDREW S. PODGORSKI (National Research Council of Canada, Div. of Electrical Engineering, Ottawa) IN: IEEE 1990 International Symposium on Electromagnetic Compatibility, Washington, DC, Aug. 21-23, 1990, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 218-223. refs
Copyright

The lightning peak current amplitudes and peak current derivatives recorded on short and tall towers and aircraft and

obtained through EM field measurement in the high probability of occurrence region are successfully verified with the use of a unified lightning threat concept. The lightning peak current amplitudes and peak current derivatives are then extended to the low probability of occurrence region to determine the anticipated values of both variables. A comparison of the existing standards for protection of an aircraft with the anticipated peak current amplitudes and peak current derivatives is presented along with conclusions concerning the adequacy of existing standards. I.E.

A92-15175
MANAGEMENT DECISIONS HAVE AN IMPACT ON FLIGHT SAFETY
DANIEL MAURINO (ICAO, Air Navigation Bureau, Montreal, Canada) ICAO Journal (ISSN 0018-8778), vol. 46, Oct. 1991, p. 6-9.

Decision-makers concerned with aviation at the system-level are ideally placed to improve flight safety through improvements in system cohesiveness and training. A direct relationship is established between management deficiencies and accident/incident precursors. Deficiencies in training may lead to such precursors as high workloads which may coexist with failures in maintenance and scheduling; these may in turn exacerbate workloads and pressures. Failures in system control may allow the pairing of inexperienced crewmembers or operations under unacceptably adverse conditions. O.C.

A92-16050
FLIGHT SAFETY; PROCEEDINGS OF THE CONFERENCE, LONDON, ENGLAND, NOV. 21, 1991
Conference sponsored by Royal Aeronautical Society. London, Royal Aeronautical Society, 1991, 69 p. No individual items are abstracted in this volume.

The present conference discusses a civil operator's perspectives on helicopter operation safety in the North Sea region, commercial safety-related aspects of corporate helicopter operations, and the relationship of British safety legislation to the continued airworthiness of light civil helicopters. Also discussed are military perspectives on helicopter flight safety, human factors-related issues in helicopter accident analyses, investigative methods applicable to helicopter accidents, and the application of novel technologies for enhancing helicopter safety. O.C.

A92-16137
STUDY OF SIMULATED LIGHTNING DISCHARGE EFFECTS ON WIRES OF A ROTORCRAFT
M. LEMISTRE (ONERA, Chatillon, France) and J. L. EMANUELY (Toulouse, Centre d'Essais Aeronautiques, France) (European Rotorcraft Forum, 17th, Berlin, Federal Republic of Germany, Sept. 24-27, 1991) ONERA, TP no. 1991-173, 1991, 14 p. refs
(ONERA, TP NO. 1991-173)

Four major parameters characterizing real lightning strokes have been simulated in the course of a study of indirect effects of lightning discharges on a helicopter. Three different simulation methods were employed: high current-pulse injection, low-level CW current injection, and high-voltage arc coupling. The electrical coupling phenomenon on high impedance wires is revealed. O.C.

A92-17252
ENGINE AIR INLET AND DE-ICING SYSTEM - AT -30 C IN THE ICING TUNNEL OF NRC OTTAWA
THOMAS VOGELBACHER Dornier Post (ISSN 0012-5563), no. 3, 1991, p. 68, 69.

The Canadian National Research Council's (NRC) Ottawa icing-studies wind tunnel has been used to test the engine air intake deicing system of the Do 328 aircraft. The deicing system employs neoprene rubber boots that are conformal when deflated and vaulted when inflated by pressurized air. The NRC icing wind tunnel allowed testing to be conducted with careful control of ambient temperature, pressure altitude, water droplet diameter and number, cloud size and type, aircraft flight speed, and structural surface geometry. O.C.

N92-13039# National Transportation Safety Board, Washington, DC.
AIRCRAFT ACCIDENT REPORT: MARKAIR, INC., BOEING 737-2X6C, N670MA, CONTROLLED FLIGHT INTO TERRAIN, UNALAKLEET, ALASKA, 2 JUNE 1990
23 Jan. 1991 90 p
(PB91-910402; NTSB/AAR-91/02) Avail: NTIS HC/MF A05 CSCL 01/3

On 2 Jun. 1990, at 0937 Alaskan Daylight Time, MarkAir, Inc. flight 3087, a Boeing 737-2X6C, registered in the U.S. as N670MA, crashed about 7.5 miles short of runway 14, Unalakleet, Alaska, while executing a localizer approach to that runway. The flight originated at 0828 at Anchorage International Airport. Instrument meteorological conditions existed at the time, and a flight attendant sustained minor injuries. Another flight attendant sustained serious injuries. There were no passengers on board, and the airplane was destroyed. The flight was operated under FAR Part 121. The National Transportation Safety Board determines that the probable cause of this accident was deficiencies in flightcrew coordination, their failure to adequately prepare for and properly execute the UNK LOC Rwy 14 nonprecision approach and their subsequent premature descent. The safety issues that are discussed include cockpit resource management and approach chart symbology. This safety board issued a safety recommendation on approach chart standardization to the FAA. Safety recommendations were also issued to MarkAir, Inc., on the subjects of cockpit resource management and checklist usage. Author

N92-13040# National Academy of Sciences - National Research Council, Washington, DC. Committee for the Study of Air Passenger Service and Safety Since Deregulation.
WINDS OF CHANGE: DOMESTIC AIR TRANSPORT SINCE DEREGULATION
1991 415 p
(NRC-SR-230; ISBN-0-309-05104-5; LC-91-22773) Avail: NTIS HC/MF A18

A committee appointed by the National Research Council studied the effects of the Airline Deregulation Act of 1978 on domestic, commercial aviation, particularly on air passenger service, airline safety, airway capacity, and airline service quality. Both private and public sector issues were addressed. Issues such as the appropriate level of foreign investment in U.S. airlines were not examined. Deregulation has served to concentrate more of the market in fewer airlines, has contributed to intense competition, rapid change, and to some airlines' financial trouble. The committee makes specific recommendations for prudent government actions to improve competition, safety, and capacity, and also recommends a more thorough study to determine how best to organize the Federal Aviation Administration to act better on its responsibilities. It is noted that successful deregulated airlines have better management, are more effective competitors, and are likely to hold their own in future, global competition, but that financially weakened airlines, and the diminished number of airlines, are causes for concern. J.P.S.

N92-13041# Defence and Civil Inst. of Environmental Medicine, Downsview (Ontario).
DEVELOPMENT OF AN EMERGENCY UNDERWATER ESCAPE BREATHING SYSTEM FOR CH124 SEAKING AIRCREW
WAYNE R. STURGEON Apr. 1988 20 p
(DCIEM-87-TR-11; CTN-91-60227; AD-B123560L) Avail: NTIS HC/MF A03

A description is provided of research into and development of an underwater escape breathing system for use by Canadian Forces aircrew faced with the risk of water immersion and underwater escape from a downed aircraft. Details of a preliminary investigation of the U.S. Coast Guard Rebreather System are included. In addition, two other systems were evaluated: the Robertshaw system which was based on a SCUBA design and

the Submersible Systems Inc. (SSI) system which was designed as an underwater escape system for divers. After several modifications and further testing, the SSI underwater escape breathing system was recommended for adoption by the Canadian Forces. Author (CISTI)

N92-13042# Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
AIR-TO-AIR VISUAL ACQUISITION HANDBOOK
J. W. ANDREWS 27 Nov. 1991 76 p
(Contract DTFA01-85-Z-02015; F19628-90-C-0002)
(ATC-151; DOT/FAA/PM-87/30) Avail: NTIS HC/MF A05

Described here is a set of computer programs that provide a practical means for predicting air-to-air visual acquisition performance for aircraft on collision courses. The programs are based upon a mathematical model of pilot visual acquisition performance. Guidelines are provided for selecting model parameters based upon previously collected flight test data. Selected results of computer analysis are provided. Author

N92-13043# Federal Aviation Administration, Atlantic City, NJ.
ONBOARD CABIN WATER SPRAY SYSTEM UNDER VARIOUS DISCHARGE CONFIGURATIONS
TIMOTHY MARKER Oct. 1991 27 p
(DOT/FAA/CT-TN91/42) Avail: NTIS HC/MF A03

Six full-scale fire tests were conducted in a modified DC-10 fuselage to investigate the effects of spraying water at different cabin locations or pre-wetting the cabin, while keeping the fire conditions constant. The tests were part of a 28 test series using a wide body fuselage to study the performance of an onboard cabin water spray system. The spray system utilizes low flow rate nozzles which produce a fine mist consisting of a range of water droplet diameters. The system being tested was a breadboard design for the purpose of demonstrating concept feasibility only. Two tests involved spraying water in different sections of the cabin and overhead. Two other tests investigated the effects of spraying varying quantities of water before the fire was ignited to pre-wet the interior. For comparison, one test used spray throughout the cabin, while the last test performed was without water in order to establish a baseline. Temperature, smoke, heat flux, and gas concentrations were monitored at various locations throughout the fuselage. Author

N92-13044*# Miami Univ., Coral Gables, FL. Dept. of Management Science.
THE IMPACT OF COCKPIT AUTOMATION ON CREW COORDINATION AND COMMUNICATION. VOLUME 1: OVERVIEW, LOFT EVALUATIONS, ERROR SEVERITY, AND QUESTIONNAIRE DATA
EARL L. WIENER, THOMAS R. CHIDESTER, BARBARA G. KANKI, EVERETT A. PALMER, RENWICK E. CURRY, and STEVEN E. GREGORICH (San Jose State Univ., CA.) Nov. 1991 152 p
Sponsored by FAA
(Contract NCC2-581)
(NASA-CR-177587; NAS 1.26:177587) Avail: NTIS HC/MF A08 CSCL 01/3

The purpose was to examine, jointly, cockpit automation and social processes. Automation was varied by the choice of two radically different versions of the DC-9 series aircraft, the traditional DC-9-30, and the glass cockpit derivative, the MD-88. Airline pilot volunteers flew a mission in the simulator for these aircraft. Results show that the performance differences between the crews of the two aircraft were generally small, but where there were differences, they favored the DC-9. There were no criteria on which the MD-88 crews performed better than the DC-9 crews. Furthermore, DC-9 crews rated their own workload as lower than did the MD-88 pilots. There were no significant differences between the two aircraft types with respect to the severity of errors committed during the Line-Oriented Flight Training (LOFT) flight. The attitude questionnaires provided some interesting insights, but failed to distinguish between DC-9 and MD-88 crews. Author

N92-13045# Federal Aviation Administration, Washington, DC.
AIRPORT ACTIVITY STATISTICS OF CERTIFICATED ROUTE AIR CARRIERS: CALENDAR YEAR 1990 Report, period ending 31 Dec. 1990
1990 544 p
(AD-A241483) Avail: NTIS HC/MF A23 CSCL 01/3

This report contains summary tables regarding: Summary of aircraft departures, enplaned revenue passengers, and enplaned revenue tons of cargo and mail by type of service, by carrier group, and by air carrier; Summary of aircraft departures, enplaned passengers, and enplaned revenue tons of cargo and mail by type of service, by state and U.S. Area; Aircraft departures, enplaned revenue passengers, and enplaned revenue tons of cargo and mail in total operations, all services at large air traffic hubs; Aircraft departures, enplaned revenue passengers, and enplaned revenue tons of cargo and mail in total operations, all services at medium air traffic hubs; Aircraft departures, enplaned revenue passengers, and enplaned revenue tons of cargo and mail in total operations, all services at small air traffic hubs. It contains detailed tables regarding: Enplaned revenue passengers, enplaned tons of cargo and mail, and air traffic hub classifications, by type of service, by community, and by carrier; and Aircraft departures scheduled and aircraft departures performed, by aircraft type, by community, and by carrier. GRA

N92-13046# Federal Aviation Administration, Washington, DC.
FAA AIR TRAFFIC ACTIVITY: FY 1990. ADDENDUM Statistical Report, 1 Oct. 1989 - 30 Sep. 1990
1990 217 p
(AD-A241484) Avail: NTIS HC/MF A10 CSCL 01/5

This FAA publication furnishes terminal and en route air traffic activity information of the National Airspace System. The data have been reported by the FAA-operated Airport Traffic Control towers (ATCTs), Air Route Traffic Control Centers (ARTCCs), Flight Service Stations (FSSs/AFSSs/IFSSs), Approach Control Facilities, and FAA contract-operated towers. These reports are used as a guide in determining the need for larger or additional facilities and possible increases in personnel at existing facilities. GRA

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

A92-13851
THE AERONAUTICAL MOBILE SATELLITE SERVICE (AMSS). I - ARCHITECTURE OF THE AMSS SYSTEM [LE SERVICE MOBILE AERONAUTIQUE PAR SATELLITES /AMSS/. I - L'ARCHITECTURE DU SYSTEME AMSS]
FRANCIS BRANGIER (Direction Generale de l'Aviation Civile, Centre d'Etudes de la Navigation Aerienne, Orly, France) Navigation (Paris) (ISSN 0028-1530), vol. 39, Oct. 1991, p. 479-489. In French. refs
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The principal technical features of the ICAO AMSS architecture as currently defined are presented. Attention is given to the satellites comprising the AMSS, the airborne instrumentation, the ground-based instruments, and the regional communication coordination control centers. Consideration is also given to the specific communication channels to be utilized, present limitations of the system and the means provided for future expansion. R.E.P.

A92-13852
THE AERONAUTICAL MOBILE SATELLITE SERVICE (AMSS). II - FREQUENCY SPECTRUM REQUIREMENTS FOR THE AERONAUTICAL MOBILE SATELLITE SERVICE [LE SERVICE MOBILE AERONAUTIQUE PAR SATELLITES /AMSS/. II - LE BESOIN EN SPECTRE DE FREQUENCES POUR LE SERVICE MOBILE AERONAUTIQUE PAR SATELLITES]
OLIVIER CAREL (Direction Generale de l'Aviation Civile, Direction de la Navigation Aerienne, Paris, France) Navigation (Paris) (ISSN 0028-1530), vol. 39, Oct. 1991, p. 489-495. In French.
Copyright

An overview is presented of the necessity for an expanded frequency spectrum to satisfy the requirements of the AMSS. Several frequencies have already been removed from the aviation sector to be authorized instead for ground mobile operators. The proposals submitted by ICAO for consideration by the International Telecommunication Union controlling body include a spread of frequencies reserved exclusively for commercial aviation to insure safety of operations at all times. R.E.P.

A92-13854
CURVED LANDING APPROACHES USING ILS AND LORAN C [APPROCHE CURVILIGNE AVEC L'ILS ET LE LORAN C]
RICHARD H. MCFARLAND (Ohio University, Athens) Navigation (Paris) (ISSN 0028-1530), vol. 39, Oct. 1991, p. 535-542. In French. Translation. refs
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The combined utilization of ILS and Loran C to provide the capability to execute curved landing approaches is presented. This concept of curved approaches involves the use of a mix of the two systems for executing a curved flight track along with utilization of a current horizontal situation indicator cockpit presentation for the pilot. It is concluded that a combination of the signal from the two systems with computational and display capabilities on board the aircraft can provide for other than the common, straight-in approach to landing. R.E.P.

A92-14045
DATA-LINK COMMUNICATION BETWEEN CONTROLLERS AND PILOTS - A REVIEW AND SYNTHESIS OF THE SIMULATION LITERATURE
KAROL KERNS (Mitre Corp., McLean, VA) International Journal of Aviation Psychology (ISSN 1050-8414), vol. 1, no. 3, 1991, p. 181-204. Research supported by FAA. refs
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The simulation literature on data-link communication between controllers and pilots is reviewed. General effects of the data-link technology on the volume, speed, and timing of air traffic control communications are analyzed. It is concluded that the combination of voice and data-link communication outperforms each medium used by itself. O.G.

A92-14403
AUTOMATIC LINK ESTABLISHMENT - THE KEY TO RELIABLE HELICOPTER NOE COMMUNICATIONS
GERALD A. BRADLEY (Bendix/King, Olathe, KS) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 1067-1073.
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Automatic link establishment (ALE) is a new waveform standard designed to manage HF communications frequency selection and radio operations. The waveform is described and the implementation and operation of a helicopter-mounted AN/ARC-199 ALE HF radio is discussed. Test results of an evaluation program are presented which show the helicopter HF communications reliability for NOE (nap-of-the-earth) operations at ranges of 8 to 236 Km and at all times of day. It is shown that NOE HF voice communications reliability exceeds 90 percent using ALE for all ranges and times of day. Author

A92-14404
GPS-INS INTEGRATION REQUIREMENTS FOR ROBUST NOE HELICOPTER NAVIGATION
JOHN R. COFFEE (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 1075-1082. refs
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The integration of a global positioning system (GPS) receiver with a strapdown inertial navigation system (INS) is examined in order to provide accurate, robust navigation capability for a modern attack helicopter. Terrain masking during nap-of-earth (NOE) flight restricts the availability of GPS satellite signals which can reduce the amount of data provided by a GPS receiver. Two GPS-INS integration methods that have been used in integrated navigation system designs (1) providing the INS Kalman filter with pseudorange and pseudorange-rate measurements for each tracked GPS satellite and (2) providing the INS Kalman filter with GPS receiver derived position and velocity fixes, are considered for an attack helicopter navigation system. The navigation performance of these two schemes is compared for a simulated NOE attack helicopter mission over actual terrain. The performance analysis shows that integration of the GPS receiver with an INS using pseudorange and pseudorange-rate data provides overall navigation accuracy of about twice that of position and velocity fix integration. It can also significantly increase attack helicopter mission effectiveness in an NOE environment. Author

A92-14429
DAY/NIGHT ADVERSE WEATHER PILOTAGE SYSTEM (D/NAPS)
RUDOLPH T. SCHWAB and ROBERT C. HOOD (U.S. Army, Aviation Systems Command, Fort Eustis, VA) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 1429-1431.
Copyright

The D/NAPS program is a four-year three-phase project intended to flight-demonstrate the integration of advanced technology in sensors, computing methods, flight controls, and displays to maximize combat-helicopter mission effectiveness and survivability in day/night adverse weather conditions. The program focus is the development of pilot cognitive-decision-aiding (CDA) through the application of artificial intelligence and the integration, but not development, of advanced pilotage sensors, controls, and displays. The first phase of the project is directed toward development of a CDA system using contractor-selected baseline aircraft and mission-equipment packages modeled in the contractor's simulator facilities. The effectiveness of the CDA system is measured by comparing the performance of a baseline aircraft system against the performance of the baseline aircraft system equipped with the CDA system. The second phase involves the integration of candidate D/NAPS hardware and software with applicable mission equipment and aircraft systems, in a hot bench. The third phase is an actual flight demonstration of the D/NAPS. Author

A92-14444* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
COMPUTER AIDING FOR LOW-ALTITUDE HELICOPTER FLIGHT
HARRY N. SWENSON (NASA, Ames Research Center, Moffett Field, CA) AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Paper. 17 p. Previously announced in STAR as N91-25142. refs

A computer-aiding concept for low-altitude helicopter flight was developed and evaluated in a real-time piloted simulation. The concept included an optimal control trajectory-generated algorithm based on dynamic programming, and a head-up display (HUD) presentation of a pathway-in-the-sky, a phantom aircraft, and flight-path vector/predictor symbol. The trajectory-generation algorithm uses knowledge of the global mission requirements, a digital terrain map, aircraft performance capabilities, and advanced navigation information to determine a trajectory between mission waypoints that minimizes threat exposure by seeking valleys. The pilot evaluation was conducted at NASA Ames Research Center's Sim Lab facility in both the fixed-base Interchangeable Cab (ICAB)

simulator and the moving-base Vertical Motion Simulator (VMS) by pilots representing NASA, the U.S. Army, and the U.S. Air Force. The pilots manually tracked the trajectory generated by the algorithm utilizing the HUD symbology. They were able to satisfactorily perform the tracking tasks while maintaining a high degree of awareness of the outside world. Author

A92-16228
AIRPORT SURFACE TRAFFIC AUTOMATION
ERVIN F. LYON (MIT, Lexington, MA) The Lincoln Laboratory Journal (ISSN 0896-4130), vol. 4, Summer 1991, p. 151-188. refs

The Airport Surface Traffic Automation (ASTA) program is described which uses new technologies and advanced automation techniques to enhance the work of tower controllers, pilots, and vehicle operators. Surveillance of surface traffic is improved through the use of target data from the Airport Surface Detection Equipment radar (ASDE-3), or the equivalent surface radar, along with the extension of the Mode-S beacon system to the airport surface. Automation processing is improved through new functionality that will be added to the upcoming Tower Control Computer Complex. Tower-to-cockpit communications are augmented by a system of automatically controlled surface lights and a Mode-S two-way digital data link. O.G.

A92-16252
A KA-BAND INSTRUMENTATION RADAR WITH ONE FOOT RANGE RESOLUTION
R. S. ROBERTSON, M. AUTRY, and C. BRENNEISE (Hughes Aircraft Co., Missile Systems Group, Canoga Park, CA) IN: 1991 IEEE National Radar Conference, Los Angeles, CA, Mar. 12, 13, 1991, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1991, p. 1-5. refs

The design and performance of an instrumentation-quality, real-time, millimeter-wave radar system are presented. This pulsed, Ka-band radar is polarimetric diverse, bi-phase coded, and stepped frequency agile, pulse to pulse. A two-stage pulse compression process is employed to achieve a variable range resolution from 5 m to 1 ft upon computer command. Real-time processing is achieved with a four-processor system. The radar has been successfully employed in a Doppler beam sharpening experiment against an array of corner reflectors in a clutter background. I.E.

A92-16257
MULTIPLE PHASE CENTRE DPCA FOR AIRBORNE RADAR
L. LIGHTSTONE (Atlantis Scientific Systems Group, Inc., Ottawa, Canada), D. FAUBERT, and G. REMPEL (Defence Research Establishment Ottawa, Canada) IN: 1991 IEEE National Radar Conference, Los Angeles, CA, Mar. 12, 13, 1991, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1991, p. 36-40. refs

The performance of airborne displaced phase center antenna (DPCA) systems with two or more receive phase centers is studied. The detection capability of these radar systems is examined in terms of signal-to-interference ratio (SIR) as a function of target radial speed. The results indicate that DPCA can perform better than a single phase center radar (in terms of SIR). For ideal DPCA with optimal processing, an important factor in detecting the slowest possible target is not the number of receive phase centers but the maximum separation between the outermost receive phase centers. Increasing the number of phase centers, however, has an effect on the dim speeds of the system. With the binomial canceller, increasing the number of phase centers enlarges the blind speed nulls and may degrade the performance of DPCA. Internal motion degrades the performance of DPCA. The sensitivity of DPCA to increased number of phase center separation, or increased number of phase centers, in the presence of internal motion is scenario dependent. I.E.

A92-16626
INSTITUTE OF NAVIGATION, NATIONAL TECHNICAL MEETING, 47TH, PHOENIX, AZ, JAN. 22-24, 1991, PROCEEDINGS
Washington, DC, Institute of Navigation, 1991, 478 p. For individual items see A92-16627 to A92-16661.

The present conference on land, marine, aviation and space uses of GPS and Loran navigation, as well as on space-based surveillance systems, inertial guidance, and Omega/VLF radio navigation surveillance systems, gives attention to combined GPS/GLONASS data processing, dynamic GPS for railroad surveys, strategic vs tactical ATC, Loran time-difference correction factors, the DOT/DOD Federal Radio Navigation Plan, and FFT Loran time-difference corrections. Also discussed are the evaluation criteria for ground and space-based ATC surveillance, the calibration and testing of the world's most accurate gyroscope, a synergistic solution to the GPS integrity problem, GPS/Loran-C interoperability, stellar inertial navigation, the MK39-A marine strapdown laser gyrocompass, GPS for precision approaches, the statistical estimation of navigation errors, and an Omega system-status update. O.C.

A92-16627
INTEGRATING GPS WITH RANGING TRANSPONDERS
JONATHAN S. ABEL (Tetra Systems, Inc., Palo Alto, CA) and JAMES W. CHAFFEE (Science Applications International Corp., San Diego, CA) IN: Institute of Navigation, National Technical Meeting, 47th, Phoenix, AZ, Jan. 22-24, 1991, Proceedings. Washington, DC, Institute of Navigation, 1991, p. 15-24. refs

The problem of integrating GPS pseudorange measurements with transponder ranges is studied, focusing on two topics: the performance improvement noted when transponder ranges are integrated with GPS as compared to the case of GPS only, and simple methods which realize such an improvement. Fix accuracy is studied as a function of the problem geometry and, in particular, the number of GPS pseudoranges and transponder ranges available. The accuracy of position estimates is seen to be increasing with the number of pseudoranges and ranges used, with transponder ranges providing additional accuracy in directions of receiver-transponder lines of sight. A position estimator which integrates transponder ranges and GPS pseudoranges is presented and simulated. The position estimate is shown to have accuracy approaching that given by the information inequality. Author

A92-16629
THE FAA LORAN PROGRAM STATUS AND EXPECTATIONS
RICHARD P. ARNOLD (FAA, Washington, DC) IN: Institute of Navigation, National Technical Meeting, 47th, Phoenix, AZ, Jan. 22-24, 1991, Proceedings. Washington, DC, Institute of Navigation, 1991, p. 55-57.

The FAA is approaching the final stage of Loran's integration into the National Airspace System (NAS) as a navigation aid for both en route and terminal nonprecision phases of flight, constituting an earth-referenced system that supplements the station-referenced navigation aids of the NAS. It is anticipated that Loran will furnish thousands of new nonprecision approaches, entailing extensive operational and organizational adjustments within the FAA. O.C.

A92-16630
THE FUTURE OF LORAN-C NAVIGATION, INSTRUMENT APPROACHES AND FLIGHT FOLLOWING FOR AIR TRAFFIC MANAGEMENT
THOMAS P. WORKMAN (Chevron USA, Inc., Houston, TX) IN: Institute of Navigation, National Technical Meeting, 47th, Phoenix, AZ, Jan. 22-24, 1991, Proceedings. Washington, DC, Institute of Navigation, 1991, p. 65-67. refs

The Loran-C 'Flite-Track' system is a digital air-to-ground data link with extensive computer support of its operators. Each aircraft employing the system has an ONI 7000 Loran Navigation Receiver; the geographic data are channeled to the onboard data transmitter, which uses a dedicated VHF frequency to an offshore relay site. The signal is relayed by microwave transmission and dedicated

telephone lines to an airport, where it is decoded and displayed on a CRT screen. All information is stored on a computer disk. Flite-Track transmits one report every 15 sec. O.C.

A92-16631
STRATEGIC VS TACTICAL AIR TRAFFIC CONTROL UTILIZING ADS AND EARTH REFERENCE AREA NAV
CHICK LONGMAN (Air Navigation Consulting, Oklahoma City, OK) IN: Institute of Navigation, National Technical Meeting, 47th, Phoenix, AZ, Jan. 22-24, 1991, Proceedings. Washington, DC, Institute of Navigation, 1991, p. 69-72.

After discussing the shortcomings of current ATC systems, a future Air Traffic Management System (TMS) is presented which is strategically managed in such a way that tactical interventions are resorted to only when safety is compromised. Position data from earth-referenced area navigation systems are used to supplement direct radar surveillance data; point-to-point routes are used in lieu of charted airways, and charted arrival and departure routes and approach procedures are employed in place of vectors for normal operations. Loran-C furnishes an excellent basis for implementation of the present TMS. O.C.

A92-16632
OPERATIONAL AND ECONOMIC BENEFITS OF AREA NAVIGATION FROM THE PERSPECTIVE OF A MAJOR AIR CARRIER
J. M. FRANK (United Airlines, Air Traffic Systems Office, Chicago, IL) IN: Institute of Navigation, National Technical Meeting, 47th, Phoenix, AZ, Jan. 22-24, 1991, Proceedings. Washington, DC, Institute of Navigation, 1991, p. 73-77.

A92-16633
LORAN TIME DIFFERENCE CORRECTION FACTORS - VALID INFORMATION OR BLUE SMOKE AND MIRRORS?
MICHAEL J. MIRESSI (FAA, Oklahoma City, OK) and FRANKLIN D. MACKENZIE (DOT, John A. Volpe National Transportation Systems Center, Cambridge, MA) IN: Institute of Navigation, National Technical Meeting, 47th, Phoenix, AZ, Jan. 22-24, 1991, Proceedings. Washington, DC, Institute of Navigation, 1991, p. 79-81.

An evaluation is presented of the need for Loran-C time-difference (TC) correction factors to ensure that aircraft are within protected airspace, together with a technique for accuracy verification. Such accuracies are essential to standard instrument support procedure error budgets. TD correction factors allow comparisons to be conducted between local area monitors, as well as continuing refinements of corrections. O.C.

A92-16635
RAIM - WILL IT MEET THE RTCA GPS MINIMUM OPERATIONAL PERFORMANCE STANDARDS?
R. G. BROWN (Iowa State University of Science and Technology; DOT, John A. Volpe National Transportation Systems Center, Cambridge, MA), GERALD Y. CHIN, and JOHN H. KRAEMER (DOT, John A. Volpe National Transportation Systems Center, Cambridge, MA) IN: Institute of Navigation, National Technical Meeting, 47th, Phoenix, AZ, Jan. 22-24, 1991, Proceedings. Washington, DC, Institute of Navigation, 1991, p. 103-111. refs

The GPS minimum operational performance standards for supplemental navigation entails the implementation of a Receiver Autonomous Integrity Monitoring (RAIM) system. Attention is presently given to the results of extensive RAIM simulations for a modified least-squares-residuals method of failure detection. RAIM, perhaps with the aid of baroaltitude measurements, is shown to be capable of serving the civil aviation community with GPS supplemental navigation in the case of a 21-primary-satellite system constellation. O.C.

A92-16637
THE DOT/DOD FEDERAL RADIONAVIGATION PLAN
ELISABETH J. CARPENTER (DOT, John A. Volpe National Transportation Systems Center, Cambridge, MA) IN: Institute of Navigation, National Technical Meeting, 47th, Phoenix, AZ, Jan. 22-24, 1991, Proceedings. Washington, DC, Institute of Navigation, 1991, p. 125-133. Research supported by DOT.

The aspects of navigation addressed by the Federal Radionavigation Plan (FRP) encompass air, marine; land, and space operations. Military and civilian user requirements are documented and updated by the FRP to furnish a cost-effective mix of government-provided radionavigation systems. The systems covered by the FRP include Loran-C, Omega, VOR, TACAN, MLS, and GPS, among others. O.C.

A92-16638
FROM RUSSIA AND BEYOND
STEPHEN F. NUZZI (DOT, John A. Volpe National Transportation Systems Center, Cambridge, MA) IN: Institute of Navigation, National Technical Meeting, 47th, Phoenix, AZ, Jan. 22-24, 1991, Proceedings. Washington, DC, Institute of Navigation, 1991, p. 141-146. refs

Accounts are given of recent expansions of the Loran supplementary navaid system outside the National Airspace System (NAS) to the North Pacific and North Atlantic. Attention is given to the cooperative efforts which this expansion has entailed between the USA and USSR across the Bering Sea/North Pacific area. An Advisory Circular has been developed whose appendices cover flight paths outside the NAS, helping aviators select suitable equipment and locate areas of Loran coverage for greater flight safety. O.C.

A92-16639
A SIMULATOR AND PERFORMANCE CRITERIA FOR EVALUATION OF GROUND AND SPACE-BASED ATC SURVEILLANCE
J. W. SENNOTT, I. S. AHN, Y. W. LOU, and Z. TING (Bradley University, Peoria, IL) IN: Institute of Navigation, National Technical Meeting, 47th, Phoenix, AZ, Jan. 22-24, 1991, Proceedings. Washington, DC, Institute of Navigation, 1991, p. 193-201. refs (Contract DTFA01-90-P-01095)

Remote monitoring and supervisory control of aircraft during airport approach and landing is of interest. Addressed is an automatic supervisory control algorithm and a family of surveillance sensors for improved operations. System performance is obtained with an aircraft flight and surveillance simulation. Supervisory control consists of a state estimator coupled to a Latest Safe Alarm Time (LSAT) algorithm. A supervisory control performance criterion is developed. Successful alarm and false alarm probabilities are defined. The LSAT decision statistic is used to estimate the trade between successful alarm and false alarm. This trade is generated for four surveillance sensor systems: the present-day Mode C secondary surveillance radar, an improved secondary surveillance radar, a satellite system employing range measurements alone, and a satellite system employing both range and Doppler measurements. Author

A92-16641
A SYNERGISTIC SOLUTION TO THE GPS INTEGRITY PROBLEM
JOHN W. DIESEL (Litton Aero Products, Moorpark, CA) IN: Institute of Navigation, National Technical Meeting, 47th, Phoenix, AZ, Jan. 22-24, 1991, Proceedings. Washington, DC, Institute of Navigation, 1991, p. 229-236. refs

The existing GPS operational control system is shown to be capable of safely and reliably furnishing integrity warnings when out-of-tolerance conditions exist within 30 min, by setting 'health bits' in the satellite. Current commercial inertial system random walk coefficients make it possible to coast on a purely inertial basis for 30 min without exceeding the specification for nonprecision approach after GPS calibration. The system is thereby rendered capable of using only four satellites as sole navigational means for periods of up to 30 min without resort to Receiver Autonomous Integrity Monitoring. O.C.

A92-16643* Ohio Univ., Athens.
IN-FLIGHT DEMONSTRATION OF HYBRID GPS/LORAN RAIM

FRANK VAN GRAAS (Ohio University, Athens) IN: Institute of Navigation, National Technical Meeting, 47th, Phoenix, AZ, Jan. 22-24, 1991, Proceedings. Washington, DC, Institute of Navigation, 1991, p. 249-257. Research supported by FAA. refs
(Contract DTRS57-87-C-00006; NGR-36-009-017)

A receiver autonomous integrity monitoring (RAIM) scheme has been implemented in a real time, prototype hybrid GPS/LORAN receiver. A four-channel GPS receiver and an eight-channel LORAN-C receiver are used to obtain raw GPS and LORAN pseudorange measurements. The measurement data is sent to a microcomputer for position and integrity determination. Navigation data is presented to the pilot on a standard course deviation indicator with a data renewal rate of up to one update per second. Provisions are made to simulate signal malfunctions in real time by injecting step or ramp failures in the pseudorange measurements. A least-squares fault detection algorithm is presented for the detection of slowly growing measurement errors. The performance of the hybrid GPS/LORAN receiver has been demonstrated through actual flight tests. One of the flight tests is summarized in the paper. Author

A92-16644
GRACEFUL DEGRADATION OF GPS/INS PERFORMANCE WITH FEWER THAN FOUR SATELLITES
ZDZISLAW H. LEWANTOWICZ and DANNY W. KEEN (USAF, Wright-Patterson AFB, OH) IN: Institute of Navigation, National Technical Meeting, 47th, Phoenix, AZ, Jan. 22-24, 1991, Proceedings. Washington, DC, Institute of Navigation, 1991, p. 269-276. refs

Current GPS receivers require simultaneous signals from four satellites in order to calculate useful position and velocity information. Changes are recommended for existing GPS equipment, in conjunction with novel aircraft Kalman filter algorithms furnishing graceful degradation of aircraft navigation performance when only one, two, three, or intermittent satellite signals are available. These algorithms quantify the level of relative performance expected for such degraded conditions. An analysis is conducted of the relative performance of various mechanizations of the Kalman filter as a function of filter size. O.C.

A92-16646
STELLAR INERTIAL NAVIGATION GROWING WITH THE TIMES UPGRADING OF THE LN-20 INTEGRATED INERTIAL NAVIGATION SYSTEM
SCOTT W. LEWIS, MARTY HOCKBRUCKNER, and JOHN REEVE (Litton Industries, Guidance and Control Systems Div., Woodland Hills, CA) IN: Institute of Navigation, National Technical Meeting, 47th, Phoenix, AZ, Jan. 22-24, 1991, Proceedings. Washington, DC, Institute of Navigation, 1991, p. 295-302. refs

Litton's LN-20 Stellar-Inertial-Doppler-Navigation System was developed in the early seventies as an application of inertial and stellar sensor technologies which were developed in the late sixties. Throughout the eighties, Litton has updated the LN-20 system to take advantage of new technologies to improve system performance, reliability, and maintainability. This paper describes the incorporation of: a MIL-STD-1750 processor, higher-order language (JOVIAL) system software, a MIL-STD-1553 serial data bus, a Global Positioning System interface, updated optical encoder electronics, a multi-line, multi-page LED Control and Monitor Unit, a charge-coupled device array stellar sensor, ring laser gyros, a three-axis accelerometer triad, and a data-loading device for input of mission information. Author

A92-16647
BARO-INERTIAL LOOP FOR THE USAF STANDARD RLG INU
J. S. AUSMAN (Litton Industries, Guidance and Control Systems Div., Woodland Hills, CA) IN: Institute of Navigation, National Technical Meeting, 47th, Phoenix, AZ, Jan. 22-24, 1991, Proceedings. Washington, DC, Institute of Navigation, 1991, p. 303-308. refs

The purpose of a baroinertial loop is the definition of vertical velocity rather than altitude; since over the long term the inertial altitude must track the barometric altitude, the altitude output from a baroinertial loop is inappropriate for weapon delivery systems where accurate readings for altitude change are required. Attention is presently given to a baroinertial loop's mechanization in a ring-laser gyro (RLG), pursuant to the USAF Standard RLG inertial navigation unit specification. Simulation results illustrating loop performance under flight maneuvering and barometric errors are presented. O.C.

A92-16649
PRECISION APPROACH USING GPS AND GLONASS
PAUL M. CREAMER and E. M. GEYER (Analytic Sciences Corp., Reading, MA) IN: Institute of Navigation, National Technical Meeting, 47th, Phoenix, AZ, Jan. 22-24, 1991, Proceedings. Washington, DC, Institute of Navigation, 1991, p. 331-339. Research sponsored by DOT. refs

An evaluation is made of the ability of the GPS and GLONASS satellite navigation systems to permit ILS- or MLS-quality instrument approach procedures at runways anywhere on the globe, independent of ground equipment. The capabilities of the baseline GPS and GLONASS systems fall far short of earth-referenced RNAV-level precision approaches; a set of potential enhancements for these systems, encompassing differential operation, pseudolites, and geostationary overlay, is accordingly considered and quantified in terms of achievable accuracy and availability. A plan for the earliest practical implementation of a GPS/GLONASS precision-approach capability is presented. O.C.

A92-16650* Honeywell, Inc., Minneapolis, MN.
DESIGN AND FLIGHT TEST OF A DIFFERENTIAL GPS/INERTIAL NAVIGATION SYSTEM FOR APPROACH/LANDING GUIDANCE
LAWRENCE VALLOT, SCOTT SNYDER, BRIAN SCHIPPER (Honeywell Systems and Research Center, Minneapolis, MN), NIGEL PARKER (Honeywell, Inc., Clearwater, FL), and CARY SPITZER (NASA, Langley Research Center, Hampton, VA) IN: Institute of Navigation, National Technical Meeting, 47th, Phoenix, AZ, Jan. 22-24, 1991, Proceedings. Washington, DC, Institute of Navigation, 1991, p. 341-352. refs

NASA-Langley has conducted a flight test program evaluating a differential GPS/inertial navigation system's (DGPS/INS) utility as an approach/landing aid. The DGPS/INS airborne and ground components are based on off-the-shelf transport aircraft avionics, namely a global positioning/inertial reference unit (GPIRU) and two GPS sensor units (GPSSUs). Systematic GPS errors are measured by the ground GPSSU and transmitted to the aircraft GPIRU, allowing the errors to be eliminated or greatly reduced in the airborne equipment. Over 120 landings were flown; 36 of these were fully automatic DGPS/INS landings. O.C.

A92-16651
A PRELUDE TO INTEROPERABILITY - COMMENTS ON THE LACK OF FEDERAL RADIONAVIGATION PLAN PROCEDURES FOR ASSESSING THE POTENTIAL OF A CANDIDATE SYSTEM TO FIT INTO THE MIX OF DOMESTIC RADIONAVIGATION SYSTEMS
EDWARD L. MCGANN (Megapulse, Inc., Bedford, MA) IN: Institute of Navigation, National Technical Meeting, 47th, Phoenix, AZ, Jan. 22-24, 1991, Proceedings. Washington, DC, Institute of Navigation, 1991, p. 355-360. refs

This paper presents a series of recommendations regarding the preparation of the Federal Radionavigation Plan (FRP) which are intended to expand and strengthen the assessment process addressing the acceptability of candidate radionavigation systems for a role (or roles) in the U.S. official mix of systems. The recommendations also strongly suggest more opportunity for non-government involvement and a higher level political visibility for the organization responsible for preparing the FRP - a level which would more assertively represent the interests of the huge, growing and diverse community of radionavigation system users. Author

A92-16652
THE STATISTICAL ESTIMATION OF NAVIGATION ERRORS

W. A. POOR (Mitre Corp., McLean, VA) IN: Institute of Navigation, National Technical Meeting, 47th, Phoenix, AZ, Jan. 22-24, 1991, Proceedings. Washington, DC, Institute of Navigation, 1991, p. 361-369. refs

An algorithm is presented for the estimation of navigational system accuracy without the use of ground truth data, using a minimum of three systems. The estimates are expressed in terms of system-covariance matrices and relative bias vectors. If one of the navigation systems in question is a dead-reckoning or inertial system, the algorithm also estimates a drift-rate parameter. The results of Monte Carlo testing are confirmed by a summary of such tests conducted in USN ships. O.C.

A92-16654
AN ELECTRONICALLY SCANNED PRECISION RUNWAY MONITOR
DENIS A. GREENING and ALLEN I. SINSKY (Allied-Signal Aerospace Co., Bendix Communications Div., Towson, MD) IN: Institute of Navigation, National Technical Meeting, 47th, Phoenix, AZ, Jan. 22-24, 1991, Proceedings. Washington, DC, Institute of Navigation, 1991, p. 393-398.

An electronically scanned precision runway monitor serving as a secondary surveillance radar system is being demonstrated in the task of air traffic monitoring on instrument approaches to closely spaced parallel runways. Phased-array technology is employed to update aircraft position data more frequently than is currently possible with conventional, mechanically-steered systems. It is expected that this capability will allow the 4,300-ft runway separation standard to be reduced to less than 3000 ft. An account is presently given of the runway monitor's installation and color graphics display. O.C.

A92-16655
DEVELOPMENTS IN AIRBORNE SURVEILLANCE AND CONTROL SYSTEMS
D. BURNETTE, R. E. HENDRIX, G. KAHLON, M. MICHAEL, P. J. QUEENEY, and W. R. GRETSCH (Westinghouse Electric Corp., Electronic Systems Group, Baltimore, MD) IN: Institute of Navigation, National Technical Meeting, 47th, Phoenix, AZ, Jan. 22-24, 1991, Proceedings. Washington, DC, Institute of Navigation, 1991, p. 399-403.

A comprehensive development status evaluation is presented for retrofit, current, and prospective systems for airborne early warning (AEW) and command/control/communications. Such systems must reliably operate over land and sea, as well as at the critical land/sea boundary, in long-duration missions. Attention is given to possibilities for airship-based AEW in which radar antennas are incorporated either internally or conformally, on 'smart' skins; such skins may also be used on conventional aircraft and high altitude unmanned aircraft. O.C.

A92-16656
SABERLINER FLIGHT TEST AND RESULTS FOR FORWARD LOOKING DETECTION AND AVOIDANCE OF AIRBORNE WINDSHEAR
BRUCE D. MATHEWS (Westinghouse Electric Corp., Baltimore, MD) IN: Institute of Navigation, National Technical Meeting, 47th, Phoenix, AZ, Jan. 22-24, 1991, Proceedings. Washington, DC, Institute of Navigation, 1991, p. 405-410. refs

A flight test has been conducted of the AN/APG-68 instrumented radar in order to assess the urban discrete/ground moving-vehicle clutter environment, using radar mode timing, waveform, and signal-processing configuration suitable for microburst-windshear avoidance. FFT data were collected below 2000 ft altitude in both the mainbeam and sidelobe regions. The clutter environment results obtained furnish an empirical foundation for low false alert detection-algorithm development. Far sidelobes of ostensibly 30-inch diameter flat-plate phased arrays are found to be adequate. O.C.

A92-16657
TCAS IN THE 1990S
JOSEPH WALSH and JOHN WOJCIECH (FAA, Research and Development Service, Washington, DC) IN: Institute of Navigation, National Technical Meeting, 47th, Phoenix, AZ, Jan. 22-24, 1991, Proceedings. Washington, DC, Institute of Navigation, 1991, p. 411-420.

Existing ATC radar transponders furnish the basis for the new Traffic Alert and Collision Avoidance System (TCAS), which can provide immediate protection against the large population of aircraft that are already transponder-equipped. By using transponder information to track nearby aircraft, advisory data can be displayed in the cockpit to assist the pilot in threat-aircraft avoidance. An account is given of three different versions of TCAS, the third of which is still under development, and TCAS implementation plans for the 1990s. O.C.

A92-16658
THE 1990 FEDERAL RADIONAVIGATION PLAN AND ITS IMPACT ON THE OMEGA NAVIGATION SYSTEM
HEYWOOD O. SHIRER (DOT, Research and Special Programs Administration, Washington, DC) IN: Institute of Navigation, National Technical Meeting, 47th, Phoenix, AZ, Jan. 22-24, 1991, Proceedings. Washington, DC, Institute of Navigation, 1991, p. 423-430.

The Federal Radionavigation Plan (FRP) attempts to arrive at an optimum mix of federally-furnished common-use radionavigation systems by determining which current systems might be usefully supplanted by prospective ones. FRP is of international significance in virtue of its operation of such systems as Omega jointly with other nations. The present discussion of the FRP as of 1990 emphasizes the consequences for Omega, in which recapitalization costs have been a major concern. Omega aviation service requirements will remain until there is a suitable replacement. O.C.

A92-16659
OMEGA/VLF NOW AND INTO THE 21ST CENTURY
ANDREW STRATTON (International Omega Association, Arlington, VA) IN: Institute of Navigation, National Technical Meeting, 47th, Phoenix, AZ, Jan. 22-24, 1991, Proceedings. Washington, DC, Institute of Navigation, 1991, p. 437-442. refs

Omega has come to be widely used by civil aviation for navigation in virtue of its superior cost-effectiveness relative to INS. Dual Omega + GPS (or GLONASS) receiver installation in such aircraft will allow satellite navigation to be used as a supplemental aviation-navigation device at minimum cost to operators. Interoperation of Omega and GPS may furnish receiver-autonomous monitoring of GPS; this potential may be enhanced by making Omega, VLF communications stations, and the Soviet VLF system interoperable. Omega can be used in integrity monitoring; it is also possible to use differential Omega to increase local accuracy in aviation navigation. O.C.

A92-16660
OMEGA - GPS INTEGRATION PLATFORM
DARRELL W. DAVIS (Trimble Navigation, Austin, TX) IN: Institute of Navigation, National Technical Meeting, 47th, Phoenix, AZ, Jan. 22-24, 1991, Proceedings. Washington, DC, Institute of Navigation, 1991, p. 443-447.

The addition of a GPS-receiver feature to existing and prospective Omega navigation systems will not only enhance position accuracy but furnish an inexpensive updating capability for operators. The addition of the GPS module will be transparent to the operator; all training and operating procedures will accordingly remain the same. Due to its global coverage and outstanding accuracy, GPS is anticipated to be capable of becoming the navigation air of choice in the early 21st century. O.C.

A92-16927
DIGITAL TECHNOLOGY APPLIED TO AIRBORNE RECEIVERS
JEAN P. LACROIX (Sextant Avionique, Valence, France) IN: ION GPS-90; Proceedings of the 3rd International Technical Meeting of the Satellite Division of the Institute of Navigation, Colorado Springs, CO, Sept. 19-21, 1990. Washington, DC, Institute of Navigation, 1990, p. 41-47.

The development of single-board five to ten channel core receivers that may be used as miniaturized GPS sensors as well as modules inside an inertial reference unit or another host computer is described. Attention is focused on development of digital techniques applied to GPS receivers to enhance the accuracy of position and velocity signals. The techniques and technologies implemented, the receiver architectures selected, and the characteristics, performances, and ground and flight test results of the receivers developed are discussed. R.E.P.

A92-16934
AIRCRAFT NAVIGATION USING GLOBAL POSITIONING SYSTEM IMPROVED WITH GEOSTATIONARY SATELLITES
L. CAPORICCI, S. DI GIROLAMO (Ital Spazio S.p.A., Rome, Italy), and F. GRAZIANI (Roma I, Universita, Rome, Italy) IN: ION GPS-90; Proceedings of the 3rd International Technical Meeting of the Satellite Division of the Institute of Navigation, Colorado Springs, CO, Sept. 19-21, 1990. Washington, DC, Institute of Navigation, 1990, p. 217-224. refs

A study analyzing the real performances obtainable in the Mediterranean area by utilizing the basic GPS/NAVSTAR constellation is presented. The additional elements capable of enhancing the overall performances are also outlined. The integrated solutions considered are based on the utilization of geostationary satellites. With this approach it is possible to provide a navigation service resulting in adequate safety standards relevant to the projected traffic volume of future years. R.E.P.

A92-16935
POTENTIAL IMPACT OF GPS AND AUTOMATIC DEPENDENT SURVEILLANCE ON AIR LANE SEPARATION IN THE NORTH ATLANTIC ORGANIZED TRACK SYSTEM
H. J. ROME (Lowell, University, MA) IN: ION GPS-90; Proceedings of the 3rd International Technical Meeting of the Satellite Division of the Institute of Navigation, Colorado Springs, CO, Sept. 19-21, 1990. Washington, DC, Institute of Navigation, 1990, p. 225-236. refs

This paper outlines a methodology for evaluating collision risk and separations standards in the oceanic Organized Track System. It involves modeling normal and degraded navigation, blunders and air system faults as a weighted sum of Gaussian density functions. The model is then applied to evaluating potential separations standards, and system parameters for the North Atlantic Organized Track System when Automatic Dependent Surveillance (ADS) and GPS are operable. Results indicate that separations standards of between 10 and 15 nm are possible depending on the level of system faults. Sampling rates should be around 20/hour. Author

A92-16938
GLOBAL SATELLITE NAVIGATION USING BOTH GPS AND GLONASS
STEVEN M. CHAMBERLAIN and RAYMOND A. EASTWOOD (Magnavox Advanced Products and Systems Co., Torrance, CA) IN: ION GPS-90; Proceedings of the 3rd International Technical Meeting of the Satellite Division of the Institute of Navigation, Colorado Springs, CO, Sept. 19-21, 1990. Washington, DC, Institute of Navigation, 1990, p. 277-286. refs

A comparison is presented of the GLONASS and GPS global satellite navigation systems. The advantages of a combined receiver are discussed and the design of an integrated GPS/GLONASS receiver is described. Consideration is given to the operational status of GLONASS and a performance comparison is made with GPS utilizing actual measured data. R.E.P.

A92-16947
SATZAP - A NOVEL APPROACH TO GPS INTEGRITY
KARL KOVACH (Arinc Research Corp., Fountain Valley, CA) and ROB CONLEY (Overlook Systems Technologies, Colorado Springs, CO) IN: ION GPS-90; Proceedings of the 3rd International Technical Meeting of the Satellite Division of the Institute of Navigation, Colorado Springs, CO, Sept. 19-21, 1990. Washington, DC, Institute of Navigation, 1990, p. 387-396. refs

The SATZAP concept relies on a set of three newly developed techniques that overcome three of the most difficult problems encountered by GPS FDWSs, i.e., occurrence of a failure, seriousness of the failure, and warning the GPS user about the failure's effect. It uses the Operational Control System and on-orbit Block-II space vehicles designed and built by the DOD. SATZAP has the potential of providing a level of integrity assurance approaching VOR/DME equivalence on a global basis. R.E.P.

A92-16948
IMPLEMENTATION OF A RAIM MONITOR IN A GPS RECEIVER AND AN INTEGRATED GPS/IRS
MATS BRENNER (Honeywell Commercial Flight Systems Group, Coon Rapids, MN) IN: ION GPS-90; Proceedings of the 3rd International Technical Meeting of the Satellite Division of the Institute of Navigation, Colorado Springs, CO, Sept. 19-21, 1990. Washington, DC, Institute of Navigation, 1990, p. 397-406. refs

Honeywell has developed a sensor unit (GPSSU) and an integrated GPS/IRS (GPIRU) complying with the 743 and 704 ARINC standards for commercial avionics. A snap shot RAIM integrity monitor based on the parity space concept has been developed and is an integral part of these systems. This article discusses the algorithm and the implementation of the algorithm in the GPSSU and GPIRU. It considers the interface between the monitor and other equipment such as Flight Management Computer and navigation filters as well as testability. The ability of the snap shot RAIM monitor to isolate a failing satellite when the geometry allows will also be discussed. Results from simulation and tests of prototype equipment are presented. The predicted coverage in terms of detection and isolation for a 24 satellite constellation using the RAIM algorithm is included and related to current and future FAA requirements. Author

A92-16949
GPS AVAILABILITY. I - AVAILABILITY OF SERVICE ACHIEVABLE FOR DIFFERENT CATEGORIES OF CIVIL USERS. II - EVALUATION OF STATE PROBABILITIES FOR 21-SATELLITE AND 24-SATELLITE CONSTELLATIONS
J.-M. DURAND (CNES, Toulouse, France), T. MICHAL, J. BOUCHARD (ONERA, Chatillon, France), and A. CASEAU (Societe Generale de Techniques et d'Etudes, Ramonville-Saint-Agne, France) IN: ION GPS-90; Proceedings of the 3rd International Technical Meeting of the Satellite Division of the Institute of Navigation, Colorado Springs, CO, Sept. 19-21, 1990. Washington, DC, Institute of Navigation, 1990, p. 407-420. Translation. refs

A method is described for determining the availability of three different GPS services, i.e., supplemental navigation, sole-means navigation, and positioning when users also operate complementary equipment. This method is relevant to several different scenarios: 2D or 3D applications, different navigation phases and induced positioning accuracy requirements, and various GPS constellations, possibly supplemented by geostationary satellites. It is shown that GPS availability is highly sensitive to all these parameters. The application presented is the nonprecision approach phase in civil aviation where a 21-satellite constellation and a 24-satellite constellation are considered. R.E.P.

A92-16950
INTEGRATED USE OF GPS AND GLONASS IN CIVIL AVIATION NAVIGATION. I - COVERAGE AND DATA MODELS
P. MISRA, E. BAYLISS, R. LAFREY, and M. PRATT (MIT, Lexington, MA) IN: ION GPS-90; Proceedings of the 3rd International Technical Meeting of the Satellite Division of the Institute of Navigation, Colorado Springs, CO, Sept. 19-21, 1990. Washington, DC, Institute of Navigation, 1990, p. 425-435. Research sponsored by FAA. refs

Results from the initial phase of a program at MIT Lincoln Laboratory to support the process of examining integrated utilization of GLONASS and GPS for sole-means civil aviation navigation are presented. The coverage and data quality results together provide a basis for development of the navigation and receiver autonomous integrity monitoring algorithms for the integrated use.

The important considerations in the design of these algorithms, including the differences in the reference systems for time and space employed by the two systems, are reviewed. R.E.P.

A92-16951
COMPARISON OF FIXED AND VARIABLE THRESHOLD RAIM ALGORITHMS
MARK A. STURZA and ALISON K. BROWN (NAVSYS Corp., Monument, CO) IN: ION GPS-90; Proceedings of the 3rd International Technical Meeting of the Satellite Division of the Institute of Navigation, Colorado Springs, CO, Sept. 19-21, 1990. Washington, DC, Institute of Navigation, 1990, p. 437-443. refs

A constant probability of detection (CPOD) GPS receiver autonomous integrity monitoring (RAIM) algorithm is described. The threshold is a function of the pseudorange residual error variance, the position error alarm limit, the desired probability of detection, and the satellite geometry. The equations for calculating the thresholds and quantifying the performance of the CPOD and the constant false alarm rate are presented. R.E.P.

A92-16952
PROBABILITY DISTRIBUTIONS THAT ARE IMPORTANT WHEN ASSESSING BAROMETRIC AIDING TO GPS
M. J. A. ASBURY (Civil Aviation Authority, London, England), D. A. FORRESTER (Meteorological Office, Bracknell, England), C. S. DIXON, and R. JOHANNESSEN (STC Technology, Ltd., Harlow, England) IN: ION GPS-90; Proceedings of the 3rd International Technical Meeting of the Satellite Division of the Institute of Navigation, Colorado Springs, CO, Sept. 19-21, 1990. Washington, DC, Institute of Navigation, 1990, p. 445-453. Research supported by Civil Aviation Authority. refs
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The extent to which imperfections in the GPS coverage can be overcome by aiding from the barometric altimeter depends upon the durations of those imperfections, the variations of the barometric altimeter errors, the calibration errors and the geometries involved. The paper derives the statistical variations for all of these factors and shows that one of the most dominating features is that of the geometry between satellites and barometric input. The paper concludes that barometric aiding has potential for Supplemental Means navigation, but is unlikely to be useful for Sole Means. Author

A92-16953
THAT ALL-IMPORTANT INTERFACE
JAMES L. FARRELL (Westinghouse Defense and Electronics Systems Center, Baltimore, MD) and FRANK VAN GRAAS (Ohio University, Athens) IN: ION GPS-90; Proceedings of the 3rd International Technical Meeting of the Satellite Division of the Institute of Navigation, Colorado Springs, CO, Sept. 19-21, 1990. Washington, DC, Institute of Navigation, 1990, p. 457-460. refs

Characteristics of interface standards are reviewed and recommendations are suggested for revisions to navigation systems integration. In accordance with available techniques of correcting all deficiencies, straightforward measures are proposed whereby standards can be updated. R.E.P.

A92-16954
CLOSED-LOOP OPERATION OF GPS AIDED INS
GREGORY B. JOHNSON and ZDZISLAW H. LEWANTOWICZ (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: ION GPS-90; Proceedings of the 3rd International Technical Meeting of the Satellite Division of the Institute of Navigation, Colorado Springs, CO, Sept. 19-21, 1990. Washington, DC, Institute of Navigation, 1990, p. 461-470. refs

The operation of a GPS aided INS during vertical and horizontal maneuvers of up to nine Gs is investigated. The utilization of two Kalman filters and a decreased code loop bandwidth for increased jamming resistance tends to destabilize the closed-loop operation of the system. Results show that the GPS aided INS is stable for nominal operations, but the closed-loop system becomes unstable in filter-driving-filter configuration with a low SNR. R.E.P.

A92-16955
INS ALIGNMENT USING GPS PHASE III USER EQUIPMENT COMPUTED CORRECTIONS
PRASUN K. SINHA, DIRK DEDOES (Intermetrics, Inc., Huntington Beach, CA), and MARVIN MAY (U.S. Navy, Naval Air Development Center, Warminster, PA) IN: ION GPS-90; Proceedings of the 3rd International Technical Meeting of the Satellite Division of the Institute of Navigation, Colorado Springs, CO, Sept. 19-21, 1990. Washington, DC, Institute of Navigation, 1990, p. 471-481. refs

Phase III Global Positioning System User Equipment (RCVR3A) is being integrated into a number of host vehicle platforms whose avionics suites include a mission computer (MC) and an INS. In some platforms the memory and through-put constraints required to rapidly estimate alignment corrections militates against the mechanization of a Kalman filter in the MC. In these applications, the INS corrections computed by the RCVR3A at a 1 Hz rate offers an alternative means of correcting the INS state vector, and in particular, the INS attitude. This paper presents and discusses results obtained from in-plant tests and simulations conducted to assess the accuracies of the alignment corrections computed by the RCVR3A. Results are presented to demonstrate the utility of the RCVR3A corrections for two cases which are representative of an INS that has undergone an alignment procedure following start up, and one that has not. Author

A92-16958
FLIGHT TEST RESULTS OF AN ADA CODED INS/GPS OPEN LOOP KALMAN FILTER DESIGN
RONALD T. KELLEY (McDonnell Aircraft Co., Saint Louis, MO) IN: ION GPS-90; Proceedings of the 3rd International Technical Meeting of the Satellite Division of the Institute of Navigation, Colorado Springs, CO, Sept. 19-21, 1990. Washington, DC, Institute of Navigation, 1990, p. 505-511. refs

An open-loop Kalman-filter design is presented, and results from flight tests are analyzed to examine the filter's effectiveness in calibrating INS errors. The INS is integrated with a GPS by means of the Kalman filter which is developed and coded in the Ada Higher Order Language. The filter is designed to compute corrected navigation data when provided with INS ground alignment by transforming the data to inflight alignment (IFA) mode and processing corresponding GPS measurements. Flight tests of the filtered INS/GPS arrangement are described and demonstrate the feasibility of open-loop mechanization and improved navigational accuracy. Updated GPS data can be generated at a 10-hz rate thereby reducing GPS interpolation errors. The open-loop Kalman filter provides the means for upgrading INS designs with GPS equipment without extensive hardware and software modifications. C.C.S.

A92-16963* *Ohio Univ., Athens.*
AVAILABILITY OF POSITIONING AND RECEIVER AUTONOMOUS INTEGRITY MONITORING FOR THE GLOBAL POSITIONING SYSTEM
PAUL A. KLINE (Ohio University, Athens) IN: ION GPS-90; Proceedings of the 3rd International Technical Meeting of the Satellite Division of the Institute of Navigation, Colorado Springs, CO, Sept. 19-21, 1990. Washington, DC, Institute of Navigation, 1990, p. 555-562. Research supported by FAA. refs
(Contract NGR-36-009-017)

Receiver-autonomous integrity monitoring (RAIM) of GPS data is examined by means of a simulation of the availability of a RAIM system that can provide both a GPS coverage model and a Markov reliability model. State probabilities of GPS failure scenarios are assigned with the Markov model with a maximum of 6 simultaneous satellite failures. The parametric analysis of the failures on GPS RAIM availability includes the maximum allowable value of the horizontal dilution of precision (HDOP), the mean time to repair, and the efficacy of incorporating altimeter measurements. When the HDOP requirement is relaxed the number of RAIM outages is minimized, and poor satellite geometry can lead to a large HDOP. The use of an altimeter can also reduce outages, and RAIM availability increases with optimistic values for the mean time to repair. C.C.S.

A92-16966
WIDE AREA DIFFERENTIAL GPS
BRADFORD W. PARKINSON (Stanford University, CA), CHANGDON LEE, and PENINA AXELRAD IN: ION GPS-90; Proceedings of the 3rd International Technical Meeting of the Satellite Division of the Institute of Navigation, Colorado Springs, CO, Sept. 19-21, 1990. Washington, DC, Institute of Navigation, 1990, p. 587-598. refs

The system is designed to provide accurate sensing and positioning for aircraft approach and landing with local stations for monitoring such trajectories. The system is based on a master station with local substations and transmits vectors of error corrections that carry a variety of data-error types. The correction vectors include data on the 3D ephemeris, satellite-clock offsets, and ionospheric time delays. At the master station the data are processed with a combination of the batch-least-squares method and with either the Kalman filtering algorithm or nonlinear static estimation. A simulation of a 15-station wide-area differential GPS (WADGPS) system is conducted with existing LORAN or VOR stations. The WADGPS system is shown to effectively reduce GPS positioning errors by at least 95 percent. C.C.S.

A92-16967
A ROBUST FILTER CONFIGURATION FOR DGPS USERS
HSING-TUNG CHOU IN: ION GPS-90; Proceedings of the 3rd International Technical Meeting of the Satellite Division of the Institute of Navigation, Colorado Springs, CO, Sept. 19-21, 1990. Washington, DC, Institute of Navigation, 1990, p. 607-613. refs

This paper describes the implementation and performance of a robust filter configuration for Differential GPS users. The filter is set up to adaptively determine an error correction model while pseudo range corrections are being received from a DGPS reference station. In case the reference data link is lost, the model is used to predict the error corrections ahead. Hence, improved position accuracy over standard GPS can be maintained for a certain period of time after the loss of the correction signal from the reference station. Preliminary results of the filter implementation using actual GPS data are presented which demonstrate the efficacy of the configuration. Author

A92-16968* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
COMPENSATING USER POSITION FOR GPS EPHEMERIS ERROR
J. T. WU (JPL, Pasadena, CA) IN: ION GPS-90; Proceedings of the 3rd International Technical Meeting of the Satellite Division of the Institute of Navigation, Colorado Springs, CO, Sept. 19-21, 1990. Washington, DC, Institute of Navigation, 1990, p. 615-619. refs

A method for canceling the effect of GPS ephemeris error on user position is proposed. In this method, the baseline vectors from the reference stations to the user are estimated without adjusting the GPS ephemeris. The user position is computed by adjustment using differenced data from the user and each station separately and averaging the results with weights inversely proportional to the lengths of the baselines. Alternatively, the differenced data can be averaged in a similar manner before the user position is estimated. The averaging procedure cancels most of the ephemeris error because the error is proportional to the length of the baseline. A numerical simulation is performed to demonstrate and evaluate the method. Two reference stations with perfectly known locations are assumed to be placed several hundred kilometers apart. A user receiver with a poorly known location is located between the stations. The user positions are first estimated separately using data from the user and each station and then averaged. The averaging reduces the error by about one order of magnitude. Author

A92-16969
RESULTS OF A TEST PROGRAM FOR THE USE OF DIFFERENTIAL GPS FOR APPROACH GUIDANCE
NICO VAN DRIEL and ROBERT KRIJN (National Aerospace Laboratory, Amsterdam, Netherlands) IN: ION GPS-90; Proceedings of the 3rd International Technical Meeting of the Satellite Division of the Institute of Navigation, Colorado Springs, CO, Sept. 19-21, 1990. Washington, DC, Institute of Navigation, 1990, p. 621-629. refs

A test program of a GPS receiver is described to assess the use of differential P-code GPS for precision aircraft approaches. A research aircraft is equipped with the receiver, and a second receiver is employed in the surveyed position to broadcast differential GPS corrections. The processed data on board the aircraft provide localizer and glide-slope deviation signals and displayed on a programmable electronic flight system. Examination of the results indicates that the system is accurate to within decimeters and gives a 3D postflight aircraft trajectory. At the runway threshold the mean horizontal position error is 1.7 m, and the RMS error is 5.3 m. The mean altitude error and corresponding RMS error are -10.3 m and 7.0 m respectively. The system based on differential GPS is concluded to provide an aircraft trajectory efficiently but with some error due to resolution. C.C.S.

A92-16970
INTEGRATED NAVIGATION FOR APPROACH GUIDANCE USING DIFFERENTIAL GPS
THOMAS JACOB and MANFRED DIEROFF (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) IN: ION GPS-90; Proceedings of the 3rd International Technical Meeting of the Satellite Division of the Institute of Navigation, Colorado Springs, CO, Sept. 19-21, 1990. Washington, DC, Institute of Navigation, 1990, p. 631-636. refs

The accuracy of GPS receivers is addressed with respect to dynamic-flight-guidance applications by integrating GPS in differential mode with inertial measurement sensors. The system concept of the integrated hybrid system is explained in terms of the error behavior of stationary and dynamic applications of GPS. Real-time position information is transformed with a flight-guidance value generator and provides data for instrumentation for automated flight. The position-information data can be used by the pilot for manual flight or by the autopilot for approach and touchdown. The integrated GPS system using differential GPS is capable of providing accurate approaches and landings that comply with ICAO Cat. III requirements. C.C.S.

A92-16971
CONCEPTS FOR REPLACING SHIPBOARD TACAN WITH DIFFERENTIAL GPS
A. J. VAN DIERENDONCK (AJ Systems, Los Altos, CA) IN: ION GPS-90; Proceedings of the 3rd International Technical Meeting of the Satellite Division of the Institute of Navigation, Colorado Springs, CO, Sept. 19-21, 1990. Washington, DC, Institute of Navigation, 1990, p. 679-688. refs

The conversion of a GPS system is discussed with respect to making it an adequate replacement for the TACAN air navigation system. GPS is employed in a differential mode in conjunction with a data link that can be used at GPS frequencies with a pseudolite system or with conventional communications links. The locations of ships can be determined with the system, and the data are transmitted to an airborne receiver. The use of a conventional communication system is discussed since differential GPS (DGPS) data transfer must account for airborne and shipboard integration. Reference is made to the important nature of data encryption to the sensitive navigation data that are transferred. It is shown that the DGPS system and the GPS methodology can be used to effectively monitor the locations and possibly the velocities of ships and to facilitate navigation relative to a ship or multiple ships. C.C.S.

A92-16973
FLIGHT TEST OF A GPS-AIDED LOW-COST INERTIAL NAVIGATION SYSTEM PROGRAMMED IN ADA
JAMES E. BIRR, THOMAS J. FREY, MICHAEL D. MOBLEY, and KEVIN J. SPALDING (McDonnell Douglas Missile Systems Co., Saint Louis, MO) IN: ION GPS-90; Proceedings of the 3rd International Technical Meeting of the Satellite Division of the

Institute of Navigation, Colorado Springs, CO, Sept. 19-21, 1990. Washington, DC, Institute of Navigation, 1990, p. 697-703. refs

The embedded critical real-time application of Ada to the development of an inertial navigation system is described including the results of a flight test. The software is designed to compute navigation corrections from GPS measurements by means of a Kalman filter as well as compute position and velocity. The Ada program tracks attitude and is intended to perform scoring and data acquisition. The design takes advantage of features of an extended kernel operating system thereby permitting the Ada inertial navigation system to perform on the level of existing systems in different programming languages. The GPS-aided flight tests showed that the Ada system functioned on the level of similar FORTRAN implementations for flight scenarios with 'state-6 jamming,' 'state-3 jamming,' or GPS denial to examine free-inertial navigation-error growth. The VAXELN kernel routines can be implemented for complex synchronization communication in Ada for an inertial navigation application. C.C.S.

A92-16975
INTEGRATED GPS/INS FOR THE NATIONAL AEROSPACE PLANE
DANIEL P. JOHNSON (Honeywell Systems and Research Center, Minneapolis, MN) IN: ION GPS-90; Proceedings of the 3rd International Technical Meeting of the Satellite Division of the Institute of Navigation, Colorado Springs, CO, Sept. 19-21, 1990. Washington, DC, Institute of Navigation, 1990, p. 721-726. refs

A baseline architecture is described for the NASP vehicle including backup configurations. A preliminary performance analysis of the design during the main mission phases, including hypersonic cruise, low-earth orbit, and autonomous landing is presented. The results of several initial feasibility studies regarding the design of the navigation system for the NASP are presented. R.E.P.

A92-16976
A DIGITAL P-CODE GPS RECEIVER EMBEDDED IN THE AN/APN-217(V)5 DOPPLER NAVIGATOR
ROBERT RENNARD (Stanford Telecommunications, Inc., Santa Clara, CA) IN: ION GPS-90; Proceedings of the 3rd International Technical Meeting of the Satellite Division of the Institute of Navigation, Colorado Springs, CO, Sept. 19-21, 1990. Washington, DC, Institute of Navigation, 1990, p. 737-739.

The addition of GPS navigation to helicopters and vertical-lift aircraft is proposed by incorporating a GPS receiver into the Doppler Navigation System (DNS) AN/APN-217(V)3. The DNS presently incorporates modified software to blend the GPS and DNS navigation data from a dual-channel sequencing receiver for standard and precise positioning. Block diagrams are presented for the navigation filter structure, the system structure, and the task structure of the integration processor. The system can provide precise 3D position and velocity and can precisely give coordinated universal time. Called the AN/APN 217(V)5, the system can support target location, external system synchronization, inertial navigation system alignment, and rendezvous. The (V)5 is prepared for installation or retrofit and offers the synergistic performance of an integrated DNS/GPS system. C.C.S.

A92-17240
ADAPTIVE AIRBORNE MTI WITH TWO-DIMENSIONAL MOTION COMPENSATION
R. KLEMM (Forschungsgesellschaft fuer angewandte Naturwissenschaften, Forschungsinstitut fuer Funk und Mathematik, Wachtberg-Werthhoven, Federal Republic of Germany) IEE Proceedings, Part F: Radar and Signal Processing (ISSN 0956-375X), vol. 138, Dec. 1991, p. 551-558. refs
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Clutter returns received by an airborne radar exhibit a Doppler bandwidth which depends on the platform speed, beamwidth, and wavelength. Echoes of slow targets may, therefore, be buried in the clutter band and are difficult to detect. Perturbations of the flight path due to the flight dynamics of the aircraft and wind effects may cause further degradation of the MTI performance. It has been shown earlier that space-time FIR filters applied to the output signals of a linear array antenna can be used to compensate adaptively for the flight path component of the platform motion so that a large improvement in signal-to-clutter-noise ratio can be obtained. These ideas are extended to the compensation of transversal velocity components by means of a planar array with horizontal orientation. The influence of the system bandwidth is also investigated. The results obtained can be generalized to compensate for 3D perturbations of the flight path without using an inertial navigation device. Author

A92-17242
RANGING AND POSITIONING EXPERIMENTS FOR AIRCRAFT USING ENGINEERING TEST SATELLITE V
K. ITO (Ministry of Transport, Electronic Navigation Research Institute, Mitaka, Japan) IEE Proceedings, Part F: Radar and Signal Processing (ISSN 0956-375X), vol. 138, Dec. 1991, p. 571-575. Research supported by Communications Research Laboratory, Japan Air Lines Co., Ltd., and NASDA. refs
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The paper describes a ranging and positioning system using two geostationary satellites, one real and one pseudo on the ground, and gives the results of experiments. The system is designed to allow ranging and positioning of each aircraft every 0.6 s with a ranging and positioning accuracy of 100 m and 1 km, respectively. Experiments to estimate the system were performed using two aircraft: a Boeing 747 on the north Pacific route with a satellite elevation angle (EL) of about 20 deg, and a Beechcraft B99 in the domestic area of Japan with an EL of about 47 deg. The random error of the range was about 50 m in the experiment on the north Pacific route. The difference between the position of the B99 obtained with this system and that obtained with the global positioning system was about 500 m in the experiment in the domestic area of Japan. Author

N92-11988# National Research Council of Canada, Ottawa (Ontario). Flight Research Lab.
TRACKING PERFORMANCE REQUIREMENTS FOR ROTORCRAFT INSTRUMENT APPROACHES TO REDUCED MINIMA. PHASE 1: PRELIMINARY STUDY
S. W. BAILLIE, S. KERELIUK, R. SRINIVASSAN, and R. HOH (Hoh Aeronautics, Inc., Lomita, CA.) Feb. 1991 40 p
(NRC-32137-PHASE-1; IAR-AN-70-PHASE-1; CTN-91-60278)
Copyright Avail: NTIS HC/MF A03

The ability to track approach guidance (position and speed) to a low decision height (50 feet) when performing a steep instrument approach (6 to 9 degrees) in a rotorcraft clearly has a profound effect on the success of the approach. This report describes a preliminary attempt to define approach tracking standards for such approaches and includes a systematic data base upon which such standards can be based. This data base was generated in a flight experiment in which qualified rotorcraft certification test pilots evaluated the suitability of arriving at the decision height with various combinations of approach tracking error. The magnitude of tracking errors that are compatible with satisfactory pilot workload in the transition to hover and landing is well defined and tracking within these error bounds is clearly within the limits of current technology. The experiment was performed on the National Research Council of Canada's Bell 205 Airborne Simulator. Author (CISTI)

N92-12529# Wright Lab., Wright-Patterson AFB, OH.
ADAPTIVE TACTICAL NAVIGATION PROGRAM
SANDRA L. BERNING and DOUGLAS P. GLASSON (Analytic Sciences Corp., Reading, MA.) *In* AGARD, Machine Intelligence for Aerospace Electronic Systems 15 p Sep. 1991
Copyright Avail: NTIS HC/MF A14; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The Adaptive Tactical Navigation (ATN) system is a lab prototype which incorporates knowledge based software designed to perform navigation system management and decision aiding for the next generation of combat aircraft. The purpose of the ATN system is to manage a future multisensor navigation suite, dynamically selecting the most appropriate navigation equipment

to use in accordance with mission goals, mission phase, threat environment, equipment health, equipment availability, and battle damage. The ATN system encompasses functions as diverse as sensor data interpretation, diagnosis, and navigation resource planning. Author

N92-12530# Dayton Univ., OH.
LOCALLY LINEAR NEURAL NETWORKS FOR AEROSPACE NAVIGATION SYSTEMS
STEVEN C. GUSTAFSON and GORDON R. LITTLE *In* AGARD, Machine Intelligence for Aerospace Electronic Systems 8 p Sep. 1991
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Neural network software simulations for the representation and prediction of aircraft inertial navigation system (INS) data were developed. These simulations were evaluated using flight test data that sampled INS outputs at a standard rate for neural network testing and at half this rate for neural network training. The simulations used both locally linear neural networks and backpropagation trained neural networks. Locally linear neural networks have several desirable properties for this application, including interpolation of the training data and representation of linear relationships. For the flight test data, two milliradian testing accuracy was generally achieved with five successive and prior INS heading, pitch, and roll increments as inputs. Author

N92-13049# Systems Control Technology, Inc., Arlington, VA.
HELIPORT VFR AIRSPACE DESIGN BASED ON HELICOPTER PERFORMANCE Final Report
ROBERT K. ANOLL, EDWIN D. MCCONKEY, ROBERT J. HAWLEY, and MARGARET B. RENTON Aug. 1991 100 p
(Contract DTFA01-87-C-00014)
(SCT-90RR-34; DOT/FAA/RD-90/4) Avail: NTIS HC/MF A05

The results of the efforts to classify helicopters and heliports are presented based on the performance capabilities of a given rotorcraft and the projected ground and airspace available at a given heliport. Current visual flight rules (VFR) protected airspace requirements are not broad enough to cover the wide range of helicopter models and conditions in which they operate. Additionally, they do not always provide an adequate margin of safety from allowable obstructions near heliports with regard to the performance capabilities of the helicopters using those heliports. A recommendation is made to replace the single heliport imaginary surface with a system of surfaces which allow use of the heliport based on helicopter performance and also provides a safety margin between obstructions and rotorcraft climb capability. Another recommendation encourages helicopter manufacturers to include necessary performance data in their helicopter flight manuals to inform pilots of their aircraft's capability for operations at a confined area heliport or landing site. This is one of a series of five reports that addresses helicopter performance profile and their relationship to the VFR protected imaginary surfaces of approach and departure airspace at heliports. The other four are: (1) helicopter physical and performance data; (2) operational survey - VFR Heliport approaches and departures; (3) rotorcraft, acceleration, and climb performance model; and (4) helicopter rejected takeoff airspace requirements. Author

N92-13051# Federal Aviation Administration, Cambridge, MA. National Transportation Systems Center.
DESIGN CONSIDERATIONS FOR IAP CHARTS: APPROACH COURSE TRACK AND COMMUNICATION FREQUENCIES Final Report, Mar. 1990 - Jan. 1991
JORDAN MULTER, MARGARET WARNER, ROBERT DISARIO, and M. S. HUNTLEY, JR. Aug. 1991 82 p
(AD-A241482; DOT-VNTSC-FAA-91-11; DOT/FAA/RD-91/19)
Avail: NTIS HC/MF A05 CSCL 17/7

This report describes two experiments evaluating format changes on instrument approach plates (IAPs). The study used a simple chart reading task to assess information transfer in IAPs. The first experiment addressed different methods of displaying approach course information. Three methods were evaluated: font size, bold type, and reverse video. Bold type had a negligible effect on chart reading performance. Both boxing and reverse video improved the speed with which items could be found and or identified on the chart. The use of font size as a method for presenting information was clear; a larger font size, 12 point, was more effective for presenting the inbound heading, than a smaller, 9 point size. The second experiment examined the effectiveness of four different layouts for displaying radio frequencies. Three of the four layouts were similar to those found in existing charts published by NOAA, Jeppesen Sanderson, Inc. and the Canadian Department of Energy, Mines and Resources. The fourth layout was a two column layout, not currently found on existing charts. The two layouts analogous to the formats used by NOAA and Jeppesen Sanderson, Inc. resulted in similar performance. Performance in the two column layout and boxed layout was superior to performance in the NOAA and Jeppesen Sanderson, Inc. formats. Author (GRA)

N92-13052# Mitre Corp., Bedford, MA.
MOBILE MICROWAVE LANDING SYSTEM (MMLS): OPERATIONAL REQUIREMENTS FOR SETUP ACCURACY Final Report
MO R. DANESH and FREDERIC D. POWELL Aug. 1991 63 p
(Contract F19628-89-C-0001)
(AD-A241844; MTR-11120; ESD-TR-91-211) Avail: NTIS HC/MF A04 CSCL 17/7

This report examines, and determines, the accuracies required for the survey and alignment procedures in operational use of the Mobile Microwave Landing System such that the specified system accuracies will be satisfied in collocated and split-site Category 1 and 2 system deployments. The required accuracies are within the capabilities of modern survey equipment; in fact, less sophisticated methods such as pacing, or using the known length of the monitor cables, will suffice. Author (GRA)

05

AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A92-13291
COMANCHE - THE ARMED SCOUT
RICHARD DEMEIS Aerospace America (ISSN 0740-722X), vol. 29, Nov. 1991, p. 20-24.
Copyright

A development history and a current status evaluation are presented for the U.S. Army's next-generation Comanche scout helicopter, whose weapons suite will allow it to conduct air-to-air engagements against enemy helicopters. Maturing technologies, stealth features, and great ease of maintenance have been combined to allow a single airframe to accomplish both reconnaissance and attack helicopter missions. The 'fantail' rotor design employed allows excellent maneuverability in yaw, and operation in winds of up to 70 kts. Attention is given to the spectrum of weapons stores that the Comanche can carry for various mission profiles. O.C.

A92-13463
ACES II PLUS EJECTION SEAT
ROBERT B. CALKINS (McDonnell Douglas Missile Systems Co., Long Beach, CA) SAFE Journal, vol. 21, Sept.-Oct. 1991, p. 16-20.
Copyright

The ACES II PLUS ejection seat development program has as its goals the enhancement of maximum airspeed and altitude escape capabilities for the ACES II ejection seat (first introduced in 1977) to 700 knots and 70,000 ft. Simultaneously, maintenance time and costs would be reduced. An account is presently given

of ACES II PLUS design approaches, as well as of the results of subsystem and system-demonstration tests conducted thus far. Technical risks are noted to be significantly reduced by reliance on a proven ejection seat design as the basis for improvement. O.C.

A92-13465
NAVY AIRCREW COMMON EJECTION SEAT (NACES) PROGRAM SUMMARY
LOU D'AULERIO and PETER YOST (U.S. Navy, Naval Air Development Center, Warminster, PA) SAFE Journal, vol. 21, Sept.-Oct. 1991, p. 25-29.
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A total of 122 ejection tests were conducted on the NACES, in conditions ranging from 0-altitude/0-airspeed to Mach 1.5 at 51,000 ft; environmental, crash, live-subject physiology, and EMI tests were also conducted. The major problem faced was the need to incorporate the NACES on nine different crew stations without changes to the various aircraft. The final NACES design exhibits a high degree of commonality, especially among such high value consumables as cartridges and rocket motors. O.C.

A92-14327
FREQUENCY-DOMAIN IDENTIFICATION OF BO 105 DERIVATIVE MODELS WITH ROTOR DEGREES OF FREEDOM
K.-H. FU and J. KALETKA (DLR, Institut fuer Flugmechanik, Brunswick, Federal Republic of Germany) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 3-21. refs
Copyright

The present investigation attempts to ascertain whether higher-order models with rotor degrees-of-freedom can be derived from BO 105 helicopter flight test data on the basis of a system-identification approach. A frequency-domain method has been used to extract two different models of 10th and 14th order; the results thus obtained indicate that the extraction of extended helicopter models from measured rotor and rigid-body data is feasible, and furnishes a realistic description of aircraft dynamics. Verification results are presented for the prediction capabilities of a model thus identified. O.C.

A92-14331
LH WIND TUNNEL TESTING - KEY TO ADVANCED AERODYNAMIC DESIGN
CHARLES KEYS, MARC SHEFFLER, ROBERT HEMINWAY (Boeing Defense and Space Group, Helicopters Div., Philadelphia, PA), and STEVEN WEINER (Sikorsky Aircraft, Stratford, CT) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 77-87. refs
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More than 10,000 hrs of aerodynamic testing related to the LH helicopter's design were conducted in 1978-1990; powered model testing at 1/4-scale was used to define the five-blade bearingless main rotor configuration with a swept tapered planform that incorporates 13 deg of twist. Complete rotor/interaction models were used to provide data for fantail-feature tradeoff studies. The fantail's performance, stability, loads, and acoustic characteristics were verified through 3/4-scale testing in both hovering and forward flight. Many 1/6- and 1/10-scale unpowered fuselage model tests were conducted to assist in empennage, hub, and fan duct development. O.C.

A92-14332* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
RESULTS FROM A TEST OF A 2/3-SCALE V-22 ROTOR AND WING IN THE 40- BY 80-FOOT WIND TUNNEL
FORT F. FELKER (NASA, Ames Research Center, Moffett Field, CA) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 89-99. refs

A test of a 0.658-scale V-22 rotor and wing was conducted in the 40- by 80-Foot Wind Tunnel at Ames Research Center. The principal objectives of the test were to measure the wing download in hover for a variety of test configurations, and rotor performance in forward flight. Also, a limited amount of data on rotor performance in vertical climb were acquired. This paper presents the results from the test with predictions from appropriate analytical methods. A new method for presenting and interpreting wing surface pressure data in hover is described, and this method shows that the wing flap can produce substantial lift loads in hover. The rotor performance in vertical climb was underpredicted by CAMRAD/JA and by the free wake analysis EHPIC. A simple momentum theory is presented which provides good predictions of rotor performance in forward flight. Author

A92-14333
V-22 FLIGHT TEST AERODYNAMICS
WILLIAM K. GRAUER (Boeing Defense and Space Group, Helicopters Div., Philadelphia, PA) and MICHAEL K. FARRELL (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 101-106. refs
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The status of the aerodynamics and performance of the V-22 Osprey as determined from over 375 hours of flight testing on four aircraft is presented. The data were obtained during envelope expansion where true airspeeds of 280 knots have been achieved in cruise, 349 knots in a dive, and 48,000 pounds of lifting capability has been demonstrated in hover. Author

A92-14339
FLIGHT TESTING THE HANDLING QUALITIES REQUIREMENTS OF ADS-33C - LESSONS LEARNED AT ATTC
JOHNNIE A. HAM (USAF, Airworthiness Qualification Test Directorate, Edwards AFB, CA) and CHRISTOPHER P. BUTLER (U.S. Army, Aviation Technical Test Center, Fort Rucker, AL) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 195-208. refs
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The updated MIL-H-8501 requirements contained in the ADS-33C Handling Qualities Requirements for Military Rotorcraft have formed the basis for U.S. Army Aviation Technical Test Center rotorcraft-handling evaluations. These evaluations were conducted on the AH-64A and OH-58D helicopters. While the results obtained with the former validated the new specification's requirements, and refined the flight test techniques that will be employed during future flight test programs, those of the latter demonstrated frequency-domain flight test techniques and analyses. ADS-33C is found to furnish a useful guide to aircraft handling quality evaluations. O.C.

A92-14343
SAFE LIFE RELIABILITY - EVALUATION OF NEW STATISTICAL METHODS
H. L. ZION (Boeing Defense and Space Group, Helicopters Div., Philadelphia, PA) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 257-272. refs
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A comparative study is conducted between the conventional, mean-minus-three-sigma strength/top of scatter load safe-life calculation method, and a sequence of methods possessing increasing degrees of statistical rigor. Three random variables are identified as dominant in the determination of a safe life: flight loads, fatigue strength, and aircraft usage. Attention is given to two dynamic components from a 40-seat passenger-carrier rotorcraft: an aft-rotor pitch housing with a fretting-fatigue cracking mode in the vertical pin lug, and a fixed link in the aft rotor stationary control system with a fretting-fatigue cracking mode in the spherical rod end bearing housing. O.C.

A92-14345
A FULL SCALE AIRFRAME HIGH CYCLE FATIGUE TEST METHODOLOGY AND ITS APPLICATION TO THE SH-2G HELICOPTER
PAUL E. KEARY, TAM VOTHANH, and CHRIS A. TOMASHOFSKI (Kaman Aerospace Corp., Bloomfield, CT) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 285-296. refs

The present full-scale high-cycle fatigue test subjected an SH-2G helicopter airframe to constant-frequency vibratory loads which reproduce the critical strains experienced in flight at the main rotor primary forcing frequency. The vibratory loads were applied for 10 million cycles, in conjunction with steady lift loads and main-rotor torque and pitching moment, while the vehicle was suspended in such a way as to simulate a free-flight condition. These test conditions applied the proper magnitude and phasing of vibratory loads to the airframe while accelerating the fatigue loading. Attention is given to the methodology of choosing representative loading conditions. O.C.

A92-14353
THE HELICOPTER AIR-TO-AIR VALUE-DRIVEN ENGAGEMENT MODEL (HAVDEM) - PROTOTYPE DEVELOPMENT
NATHANIEL E. BENT (Decision-Science Applications, Inc., Arlington, VA) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 369-377. refs

HAVDEM, a nonreal-time helicopter air-to-air combat engagement simulation, models both helicopter hardware systems and pilots' decisions as to how those systems are used. HAVDEM gives attention to terrain utilization by the pilot-decision logic. Attention is given to the design-and-development strategy that has simultaneously maintained program goals and exposed unforeseen problems with government-supplied software, which can thereby be improved. Future developments of HAVDEM can incorporate improved sensors and coordinated behavior among flights. O.C.

A92-14361* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
FULL-SCALE INVESTIGATION OF AERODYNAMIC INTERACTIONS BETWEEN A ROTOR AND FUSELAGE
THOMAS R. NORMAN and GLORIA K. YAMAUCHI (NASA, Ames Research Center, Moffett Field, CA) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 461-486. refs
(Contract NAS2-11090)

A wind tunnel program has been conducted in the NASA Ames National Full-Scale Aerodynamics Complex to investigate the aerodynamic interactions between a full-scale helicopter main rotor and simple fuselage. This program provides the first complete, quantitative data base detailing the effects of a rotor on a full-scale fuselage. Steady fuselage and rotor loads were obtained as well as steady and unsteady fuselage pressures. Data were acquired over a range of rotor thrusts, advance ratios, and shaft tilts. As expected, results indicate that the largest effects on mean fuselage forces, moments, and surface pressures occur at low speeds and high rotor thrusts. Quantitative comparisons were made to determine the ability of small-scale tests to simulate the effect of the rotor on mean fuselage forces and pressures. Author

A92-14363
DEVELOPMENT OF AN ADVANCED PILOTED HELICOPTER SIMULATION
MARK E. DREIER, CAROL M. KIRKPATRICK, and F. M. SCHRAMM (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 505-523. refs

This paper describes the development of an advanced piloted helicopter simulation with improved fidelity in the mathematical model. Special emphasis is placed on the vector approach used in the multimode blade element aeroelastic rotor model, the intercomponent interface, and the interface between the flight model and the hardware in the loop. Early decisions to use a specialized simulation computer to perform the high-frequency model calculations and a slower but more robust mainframe to calculate the low-frequency and/or evolving parts of the model increased overall execution speed and enhanced the accuracy of the model. Further design decisions to use the same model for realtime and off-line analysis led to additional capability in loads prediction and subsystem selection. Correlation of this model with other, more sophisticated nonrealtime models is shown to be good in hover, forward flight, and nonlinear regimes such as high-speed and high-descent-rate flight. Author

A92-14364
HELICOPTER MODELING REQUIREMENTS FOR FULL MISSION SIMULATION AND HANDLING QUALITIES ASSESSMENT
JOHN R. MAYO, JOHN J. OCCHIATO, and STEVE W. HONG (Sikorsky Aircraft, Stratford, CT) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 525-541. refs

The U.S. Army Light Helicopter (LH) program has placed demanding requirements on the manufacturer's design analysis in order to provide a low risk, highly sophisticated attack helicopter for the next decade and beyond. In particular, it has emphasized the use of piloted simulation in design and in the demonstration of handling qualities specification compliance. This paper outlines the simulation model and simulator facility requirements that are considered crucial for obtaining meaningful pilot ratings and performance data. Included in this discussion are the components of an LH air vehicle model that contribute to realistic simulation, such as a blade-element rotor, nonlinear T800 engine and fuel control, detailed representation of fuselage and empennage aerodynamics and airflow interactions with the rotor, and an antitorque system. The operational considerations for integrating the air vehicle mathematical model with a motion base simulator facility are reviewed, and some lessons learned during the Army's ADS-33C assessment and full mission simulation evaluation are revealed. Author

A92-14369
ANALYSIS OF CRASH-RESISTANT FUEL SYSTEMS AND AIRFRAME STRUCTURE INTERACTION IN A CRASH ENVIRONMENT
AKIF O. BOLUKBASI (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 587-597. refs

An analytical methodology for predicting Crash-Resistant Fuel Systems (CRFS) and airframe structure interaction in a crash environment is presented. The mathematical algorithms used in the methodology including the formulation of equations of motion and numerical integration, special material models, and fluid-structure contact modeling are described in detail. Applications of this methodology to commonly used rotorcraft fuel system configurations are presented. The analysis results are compared with the available test results. The nonlinear response characteristics of the systems are identified and their significance to the design and analysis of airframe structures and CRFS is discussed. Author

A92-14370
DEVELOPMENT OF A RECLINED CRASHWORTHY CREWSEAT FOR ROTORCRAFT
GERSHON YANIV, KEN A. LOU (Simula, Inc., Phoenix, AZ), and KENT F. SMITH (U.S. Army, Aviation Applied Technology Directorate, Fort Eustis, VA) IN: AHS, Annual Forum, 47th,

Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 599-614. refs
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Reclining a rotorcraft crewseat may reduce the required cockpit height, which would lower aerodynamic drag and radar cross section. However, the effects of this seating position on aircrew survivability is not known. The present work simulates the dynamic response of a 50th-percentile male occupant in a reclined seat. Fortyfive seat configurations with various combinations of seat back, pan, and stroking angles were evaluated at four crash simulation scenarios. The conclusion of this study is that crewseats with highly reclined back angles would provide better lumbar support and reduce spinal injuries compared to the conventional 13-degree back angle crewseats. The reclined back and the reduced required seat stroking distance may result in a cockpit height reduction of about 10 percent. Author

A92-14372
FLIGHT SERVICE EVALUATION OF COMPOSITE HELICOPTER COMPONENTS
GEORGE H. MARDOIAN and MAUREEN B. EZZO (Sikorsky Aircraft, Stratford, CT) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 629-641. Previously announced in STAR as N91-11808. refs
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An assessment is presented of ten composite tail rotor spars and four horizontal stabilizers exposed to the effects of in-flight commercial service for up to nine years to establish realistic environmental factors for use in future designs. This evaluation is supported by test results of helicopter components and panels which have been exposed to outdoor environmental effects since 1979. Full scale static and fatigue tests were conducted on graphite/epoxy and Kevlar/epoxy composite components removed from Sikorsky Model S-76 helicopters in commercial operations off the Gulf Coast of Louisiana. Small scale static and fatigue tests were conducted on coupons obtained from panels exposed to outdoor conditions in Stratford, CT and West Palm Beach, Florida. The panel materials and ply configurations were representative of the S-76 components. The results are discussed of moisture analyses and strength tests on both the S-76 components and composite panels after up to nine years of outdoor exposure. Full scale tests performed on the helicopter components did not disclose any significant reductions from the baseline strengths. The results increased confidence in the long term durability of advanced composite materials in helicopter structural applications. Author

A92-14376
RESULTS OF FLIGHT TESTS OF THE BOEING SIKORSKY FANTAIL DEMONSTRATOR
NICHOLAS D. LAPPOS and KEVIN D. PHELPS (Sikorsky Aircraft, Stratford, CT) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 677-686. refs
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The fan-in-fin antitorque system is described in terms of supplementary test-flight data that address risk reduction, maneuverability, and the acoustic requirements of light helicopters. The demonstrator is a modified S-76B prototype aircraft, and ground and flight tests are described which confirm initial structural, performance, and acoustic design goals. The Fantail antitorque device is found to respond well to extreme yaw maneuvers and provide an increased allowable roll rate at high speeds. The yaw axis at low speeds is stable and highly damped, and rapid yaw turns in hover are reported to permit a predictable fan response. Snap turns, rolls, split-S rolls, and hammerheads are also reported, and the device appears to enhance the ability of the aircraft to accomplish such maneuvers. The Fantail demonstrator is an effective testbed which permits the testing of a full-sized light helicopter fan. C.C.S.

A92-14379
A COMPUTER PROGRAMME FOR THE CERTIFICATION OF HELICOPTER VERTICAL TAKE-OFF AND LANDING OPERATIONS AND AN APPLICATION TO THE S-76B HELICOPTER
H. J. G. C. VODEGEL and J. M. G. F. STEVENS (National Aerospace Laboratory, Amsterdam, Netherlands) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 721-731. refs
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In order to support civil and military customers the National Aerospace Laboratory NLR has developed a computer program START-OEI, partially under contract of The Netherlands Department of Civil Aviation (RLD). This program is used for the determination of the relevant flight procedures and the 2D continued and rejected flight paths after an engine failure in the vertical take-off or landing of a multiengined method, where energy of one source can be exchanged for that from another source. The program can be run on a personal desk computer. This computer program has been applied for the certification in The Netherlands of KLM Helicopters' S-76B for land based vertical operations from confined areas. Author

A92-14389
DESIGN OPTIMIZATION OF ROTOR BLADES FOR IMPROVED PERFORMANCE AND VIBRATION
CYNTHIA B. CALLAHAN and FRIEDRICH K. STRAUB (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 869-882. refs
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A multidisciplinary optimization tool for helicopter rotor blade design has been developed which efficiently and effectively determines blade aerodynamic and structural designs for improved performance and reduced fuselage vibrations. The comprehensive analysis code, CAMRAD/JA, forms the analysis core of the program while CONMIN's method of feasible directions provides the optimization algorithm. Blade aerodynamic and structural properties are used as design variables while rotor power required, hub loads and/or fuselage vibrations may be minimized as the objective function. The present paper describes the comprehensive application of the optimization tool to the AH-64A helicopter, including the introduction of additional design variables and objective function options. Results are presented for forward flight performance improvement, fuselage vibration reduction, and combined performance/vibration optimization. The optimized designs are shown to provide significant improvements in the design objectives. The mechanisms for the improvements and the practical suitability of the designs are evaluated. Author

A92-14390* Georgia Inst. of Tech., Atlanta.
ROTORCRAFT AIRFRAME STRUCTURAL OPTIMIZATION FOR COMBINED VIBRATION AND FATIGUE CONSTRAINTS
ASHISH K. SAREEN, DANIEL P. SCHRAGE (Georgia Institute of Technology, Atlanta), and T. S. MURTHY (Lockheed Engineering and Sciences Co., Hampton, VA) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 883-895. refs
(Contract NAS1-18458)
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This paper addresses the application of a formal optimization technique in rotorcraft airframe structural design studies to reduce the structural weight, to lower airframe vibrations, and to enhance fatigue life of the structure. Vibration and fatigue considerations in airframe design are described. An optimization methodology based on the use of a nonlinear programming technique to size airframe structural members subjected to constraints on weight, vibration response and fatigue stresses under dynamic loads, are described. The paper focuses on the development of necessary computational tools for airframe structural optimization and describes the sensitivity analysis procedure for these types of design constraints. Further, the paper describes the optimization procedure as

implemented in a computer code called DYNOPT which is a unique operational combination of several newly developed Fortran codes as well as modification of existing codes consisting of the direct matrix abstraction modules of the MSC/NASTRAN Program and CONMIN optimizer. The application of the optimization procedure is demonstrated using an elastic-line model of the Bell AH-1G helicopter airframe structure and computational results are discussed. Author

A92-14391* Sterling Software, Palo Alto, CA.
HUB AND PYLON FAIRING INTEGRATION FOR HELICOPTER DRAG REDUCTION
D. M. MARTIN (Sterling Software, Inc., Palo Alto, CA), R. W. MORT, P. K. SQUIRES (Bell Helicopter Textron, Inc., Fort Worth, TX), and L. A. YOUNG (NASA, Ames Research Center, Moffett Field, CA) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 897-912. refs
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The results of testing hub and pylon fairings mounted on a one-fifth scale helicopter with the goal of reducing parasite drag are presented. Lift, drag, and pitching moment, as well as side force and yawing moment, were measured. The primary objective of the test was to validate the drag reduction capability of integrated hub and pylon configurations in the aerodynamic environment produced by a rotating hub in forward flight. In addition to the baseline helicopter without fairings, three hub fairings and three pylon fairings were tested in various combinations. The three hub fairings tested reflect two different conceptual design approaches to implementing an integrated fairing configuration on an actual aircraft. The design philosophy is discussed in detail and comparisons are made between the wind tunnel models and potential full-scale prototypes. The data show that model drag can be reduced by as much as 20.8 percent by combining a small hub fairing with circular arc upper and flat lower surfaces and a nontapered 34-percent thick pylon fairing. Aerodynamic effects caused by the fairings, which may have a significant impact on static longitudinal and directional stability, were observed. The results support previous research which showed that the greatest reduction in model drag is achieved if the hub and pylon fairings are integrated with minimum gap between the two. Author

A92-14392
CLOSING THE LOOP ON HELICOPTER CRASHWORTHINESS DESIGN REQUIREMENTS
KENNETH B. AMER (Rand Corp., Santa Monica, CA) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 913-920. refs
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A comparative study is conducted between crash experiences of recent and early helicopter designs. The more stringent crashworthiness criteria of recent helicopters have resulted in reduced severity of injuries, as well as significantly fewer fatalities and disabling injuries/million flight hours, for crashes of up to 42 fps. It is projected that the UH-60 and AH-64 will have 26 fewer fatal and/or major injury accidents over their service life than would have been likely on the basis of statistics for earlier helicopter designs. O.C.

A92-14394
ANALYSIS OF ROTOR BLADE DYNAMICS USING EXPERIMENTAL UH-60A AIRLOADS OBTAINED AT THE DNW
MICHAEL S. TOROK and ROBERT K. GOODMAN (Sikorsky Aircraft, Stratford, CT) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 933-954. refs
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A structural dynamics model of a modern articulated helicopter rotor is validated by applying measured airloads as a forcing function to the structural model. The validation is conducted on the model as it is implemented in a comprehensive aeroelastic analysis. Accurate documentation of blade structural properties results in good blade modal predictions and an excellent agreement between predicted and measured flatwise bending moments. Good edgewise bending-moment predictions prove sensitive to coupling between the rotor system and fixed system, coupling of blade modes, and the nonlinear characteristics of the lag damper. Torsional bending moment predictions are only fair, with disagreement possibly due to inadequate modeling of the rotor control system. The generally high quality of agreement between calculated and measured blade response, and the excellent agreement between calculated blade modal frequencies and rap-test data, yields a mutual validation of the experimental data and the dynamic model. Author

A92-14395
STRUCTURAL OPTIMIZATION AND MACH SCALE TEST VALIDATION OF A LOW VIBRATION ROTOR
DARRELL K. YOUNG and FRANK J. TARZANIN, JR. (Boeing Defense and Space Group, Helicopters Div., Philadelphia, PA) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 955-968. refs
Copyright

A ten-foot diameter Mach-scaled wind tunnel test was performed to validate a four-bladed low vibration rotor design. Two different rotors were tested having identical planform, twist and airfoils. The reference rotor, similar to a scaled Model 360, was designed by using the traditional approach of keeping adequate separation between the rotor natural frequencies and the harmonic aerodynamic forcing. The low vibration rotor was defined by an analytical optimization procedure. During the wind tunnel test, hub loads were measured using a dynamically calibrated rotor balance and verified using a strain pattern analysis. The wind tunnel test results showed substantial reductions in the 4/rev vertical hub load and in the 4/rev hub moments for the low vibration rotor. As a byproduct, reductions were also measured in the vibratory bending moments. Author

A92-14396* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EXPERIMENTAL INVESTIGATION OF HELICOPTER VIBRATION REDUCTION USING ROTOR BLADE AEROELASTIC TAILORING
MATTHEW L. WILBUR (NASA, Langley Research Center; U.S. Army, Aerostructures Directorate, Hampton, VA) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 969-983. refs
Copyright

A wind tunnel investigation has been conducted to parametrically investigate the effect of blade nonstructural mass on helicopter fixed- and rotating-system vibratory loads. The data were obtained using Mach- and aeroelastically-scaled model rotor blades which allowed for the addition of concentrated nonstructural masses at multiple points along the blade radius. Testing was conducted for advance ratios ranging from 0.10 to 0.35 for ten blade mass configurations. Three thrust levels were obtained at representative full-scale shaft angles for each configuration. Results indicate that proper placement of blade nonstructural mass can provide reductions in fixed-system vibratory loads, but that correct mass placement and the loads reduction realized are dependent upon flight condition. The data base obtained with this investigation provides a comprehensive set of fixed-system shears and moments, blade moment, and blade flap and lag response. The data set is well suited for use in the correlation and development of advanced rotorcraft analyses. Author

A92-14397
FLIGHT VIBRATION TESTING OF THE V-22 TILTROTOR AIRCRAFT
M. A. RANGACHARYULU (Bell Helicopter Textron, Inc., Fort Worth, TX) and MICHAEL J. MOORE (Boeing Defense and Space Group, Helicopters Div., Philadelphia, PA) IN: AHS, Annual Forum, 47th,

Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 985-995. refs

The V-22 tiltrotor aircraft is currently in the flight test phase of its full-scale development program. During this phase, several vibration treatments have been incorporated to achieve an excellent aircraft vibration environment. These include empennage fin tuning, hub pendulum absorbers, an active vibration suppression system, and a wing fence. Vibration predictions performed before first flight accurately predicted the required treatment. Analysis, ground vibration testing, and initial flight testing have led to the successful implementation of the vibration treatment equipment. Discussions of the prediction methodology, vibration treatment techniques, and inflight vibration measurements are presented. Author

A92-14398
STUDYING DYNAMIC BEHAVIOR OF X380 HELICOPTER EQUIPPED WITH A NEW 5-BLADE COMPOSITE ROTOR
CHRISTOPHE SERR and MICHEL TROUVE (Aerospatiale, Division Helicoptere, Marignane, France) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 997-1007. refs

Flight testing of the X380 Dauphin demonstrator showed excellent vibratory comfort. The vibration level measured in flight without suspension system and with the new 5-blade rotor is better than on a conventional Dauphin with a 4-blade StarFlex rotor and suspension. The completely new 5-blade rotor design consists of a tapering composite material rotor mast and a SpheriFlex rotor head with elastomeric interblade dampers. The low vibration levels measured on the X380 are primarily attributable to the quality of the rotor and to the airframe excitation transmission characteristics. Author

A92-14399
FINITE ELEMENT CORRELATION OF THE U.S. ARMY/BHTI ACAP COMPOSITE AIRFRAME HELICOPTER
ROBERT V. DOMPKA (Bell Helicopter Textron, Inc., Fort Worth, TX) and NICHOLAS J. CALAPODAS (U.S. Army, Aviation Applied Technology Directorate, Fort Eustis, VA) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 1009-1028. refs

Results are presented from ground-vibration testing and associated NASTRAN analyses used to identify component effects on Advanced Composite Airframe Program test airframe vibration response. The objective of this effort was the identification and resolution of modeling discrepancies in order to enhance FEM modeling fidelity beyond 10-20 Hz. The systematic testing was applied to a range of test article configurations, ranging from an engineless and landing-gearless one to a 'full up' configuration. The isolation of individual component effects, including those of the stripped-down structure, furnished a unique data base well-suited for FEM model validation/improvement efforts. O.C.

A92-14406* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ADVANCED ICE PROTECTION SYSTEMS TEST IN THE NASA LEWIS ICING RESEARCH TUNNEL
THOMAS H. BOND, JAIWAN SHIN (NASA, Lewis Research Center, Cleveland, OH), and GEERT A. MESANDER (USAF, Air Logistics Center, Tinker AFB, OK) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 1111-1118. Previously announced in STAR as N91-23183. refs

Tests of eight different deicing systems based on variations of three different technologies were conducted in the NASA Lewis Research Center Icing Research Tunnel (IRT) in June and July 1990. The systems used pneumatic, eddy current repulsive, and electroexpulsive means to shed ice. The tests were conducted on a 1.83 m span, 0.53 m chord NACA 0012 airfoil operated at a 4 degree angle of attack. The models were tested at two temperatures: a glaze condition at minus 3.9 C and a rime condition at minus 17.2 C. The systems were tested through a range of icing spray times and cycling rates. Characterization of the deicers was accomplished by monitoring power consumption, ice shed particle size, and residual ice. High speed video motion analysis was performed to quantify ice particle size. Author

A92-14410
THE PRACTICAL APPLICATION OF NEW TECHNOLOGY TO THE CIVIL ROTORCRAFT NEED
JOHN F. WARD (Ward Associates, Watertown, NY) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 1159-1165. refs

The fruits of both government and industry research and development are often earmarked for integration into 'high-tech' military rotorcraft designs; the availability of the new technology then allows it to be 'pushed' into civilian applications. It is presently suggested that the proper course should be a 'pulling' of technology toward unique civilian requirements. It is recommended that a means be institutionalized for the formulation and management of a baseline document defining civil rotorcraft missions and operating requirements as industry benchmarks. O.C.

A92-14412
ROTOR BLADE PRESERVATION - GETTING THE MOST SERVICE LIFE WITH LOWEST OPERATIONAL COSTS
ROBERT B. MCNAB (Edwards & Associates, Inc., Bristol, TN) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 1171-1173.

An account is given of precautionary considerations and practical measures which helicopter operators can institute in order to derive the greatest possible service life and lowest possible operating costs from main rotor blades. Attention is given to measures that can be taken to address corrosion, abrasive erosion, cracking, statically and dynamically incurred damage, and track and balance criteria. O.C.

A92-14415* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
HIGH SPEED ROTORCRAFT - COMPARISON OF LEADING CONCEPTS AND TECHNOLOGY NEEDS
PETER D. TALBOT (NASA, Ames Research Center, Moffett Field, CA) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 1187-1212. refs

Design studies have recently been completed by Bell, Boeing, McDonnell Douglas and Sikorsky with the goal of identifying technology needs of high speed rotorcraft concepts. The general study guidelines were for 450-kt cruise speeds and low downwash characteristics. These concepts included the the folding tiltrotor, the high speed tiltrotor, the variable diameter tiltrotor, a tip-drive stopped rotor and the tilt wing. The studies have also identified technology needs of these concepts with the objective of defining a systematic program of technology development to increase confidence in the subsystems and components and achieving a low-risk design capability in the year 2000. Each contractor has reported independently on his efforts. This paper is a survey of the contractor efforts taken together, with regard to concepts, selection methods, technical issues (common and critical technologies), technology benefits and the technology plan recommendations. Author

A92-14416
THE EUROFAR VEHICLE OVERVIEW
VITTORIO CARAMASCHI (Agusta S.p.A., Varese, Italy) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p.

1213-1236. refs

This study examines the status of the Eurofar program, the aim of which is to introduce a tilt-rotor vehicle in the civil air transport scenario, focusing on all the technical, economic, and operational aspects to be considered to achieve the project's effective viability. Attention is given to the need for the program, the evolution of the air-transport project, the tilt-rotor system, the novelties of this project, its actual integrated plan, and the flight of the Demonstrator aircraft. An extended overview of the actual baseline aircraft, the concurrent technologies applied, and the experiments to be performed is given. The goals of the project's next phase are discussed. P.D.

A92-14417
CRASH-RESISTANT ROTORCRAFT PRELIMINARY DESIGN OPTIMIZATION
AKIF O. BOLUKBASI (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 1237-1248. refs

A rotorcraft preliminary design optimization methodology to achieve the desired level of crash protection with minimum possible system weight is presented. The methodology combines rotorcraft crash response analysis tools with a parametric crash-resistant subsystem weight analysis and an optimization algorithm. Application of this methodology to preliminary design of a generic military helicopter is presented. Typical data for design and crash response parameters are also presented and the significance of these design parameters to overall crash response of the system is discussed. Author

A92-14418
TIGER MGB - HIGH RELIABILITY LOW WEIGHT
MICHEL VIALLE (Aerospatiale, Division Helicoptere, Marignane, France) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 1249-1258.

The main gearbox (MGB) for the Tiger military helicopter is described with specific attention given to the gearbox architecture and the integration of the design. Following a discussion of the operational requirements the specific solutions are presented for four areas including the lubrication system, modularity, and the incorporation of advanced materials. A 3D CAD system called Catia was used to design the casings, calculate the spirobevel and cylindrical teeth, and to model casing deformations. The design of the Tiger MGB relies significantly on the integration of several functions into one part such as the ball bearings, roller bearings, and spirobevel teeth. Deep nitriding heat treatments afford a high degree of strengthening to the M50 NIL and 32 CDV 13 VIM VAR steels employed for fabrication. The advanced technological solution and the CAD software are found to be important for fulfilling the requirements of the Tiger MGB. C.C.S.

A92-14419* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
AERODYNAMIC DESIGN OF A COANDA INDUCED FORCE AND THRUSTER ANTI-TORQUE SYSTEM
HENRY R. VELKOFF (NASA, Ames Research Center; Sterling Federal Systems, Inc., Moffett Field, CA) and CHEE TUNG (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 1259-1274. refs

A general method of analysis of the external and internal aerodynamics of a generic Coanda induced circulation anti-torque system is presented. The technique gives moment about the yaw axis and download induced on the boom as well as the force developed by an aft jet. The external flows including downwash, wake swirl and the boom circulation are considered. The internal flow and losses through the duct, fan, blown slots, cascades and nozzle are considered on a step-by-step basis. Limited comparison is made with open data where available. Author

A92-14420
V-22 OSPREY TILTROTOR BLADE FOLD/WING STOW SYSTEM DESIGN AND TESTING
ROHN OLSON (Bell Helicopter Textron, Inc., Fort Worth, TX) and WILLIAM RUMBERGER (Boeing Defense and Space Group, Helicopters Div., Philadelphia, PA) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 1275-1291.

The V-22 Osprey is a tiltrotor aircraft that operates like a helicopter when taking off, and as a turboprop airplane when in high-speed forward flight. It is currently under development. The V-22 is a multimission aircraft designed for use by all four U.S. armed services. The V-22 aircraft incorporates several unique design features to meet these shipboard requirements. One such feature is the requirement to fully stow the Osprey below deck on an LHA class Navy carrier. The V-22 incorporates a blade-fold/wing-stow (BF/WS) system to meet this stowing requirement. In this paper, the control system and individual components that perform the BF/WS operations are described, as well as the functional requirements for the unique design features of the BF/WS system. The results of tests completed to date are given. Author

A92-14425
VARIATION IN HOVER AEROMECHANICAL STABILITY TRENDS WITH BEARINGLESS MAIN ROTOR DESIGN
WILLIAM H. WELLER (United Technologies Research Center, East Hartford, CT) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 1371-1384. refs

An experimental program is conducted to measure the aeromechanical stability characteristics of a bearingless main rotor model. The model is based on a four-balanced concept with a flexure, between the hub and each blade, which accommodates flatwise, edgewise, and torsional (pitch) motions. The flexure is enclosed by a torsionally stiff cuff that is cantilevered to the blade/flexure joint at its outboard end and shear-restrained to the flexure at its inboard end. The model was tested in hover over a range of rotor thrust and rotational speeds. Numerous rotor hub design parameters were varied to determine their effect on structural and aeroelastic characteristics of the model. The results in this paper show that most design changes, which were employed to increase aeromechanical stability margins, provided only negligible improvements or were detrimental in their effects. Movement of the pitch link attachment to the leading-edge does provide improved stability characteristics at the higher collective pitch angles, although the stability margins for this configurations were still small. Author

A92-14426
EVALUATION OF AN ADVANCED FINITE ELEMENT ANALYSIS FOR ROTOR BLADES
SHYI-YAUNG CHEN, ROBERT SOPHER (Sikorsky Aircraft, Stratford, CT), and OLIVIER BAUCHAU (Rensselaer Polytechnic Institute, Troy, NY) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 1385-1397. refs

The performance of an advanced finite element analysis is evaluated. The analysis preprocessor calculates the natural vibrations of a rotor blade and when linked to a primary aeroelastic code yields nonlinear responses of a rotor blade. The capability eliminates restrictions on the sizes of displacements and rotations allowed and its scope is redundant load path rotors with composite material structures. Comparisons are described between linearized modal solutions and nonlinear responses to aerodynamic and

specified loadings. Results are also given for a time-finite element analysis using physical coordinates. Author

A92-14436
CORROSION PREVENTION FIELD TEST UTILIZING WATER DISPLACEMENT COMPOUNDS
HERBERT JACOBS (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 1483-1499.
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Five different consumable materials from the water displacement compound (WDC) group of the corrosion prevention compound family were tested on a battalion of Apache AH-64A helicopters. Fifteen Apaches treated with the five WDCs were compared for corrosion efforts with three untreated control aircraft. The test results indicate that previous assumptions and predictions about WDCs showing worthwhile results that could be achieved within the capabilities of field maintenance organizations were valid. R.E.P.

A92-14443
CERTIFYING COMPOSITE HELICOPTER STRUCTURES
G. BLACHERE, P. SARLIN, and J. M. BERTHIER (Aerospatiale, Division Helicoptere, Marignane, France) AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Paper. 15 p. refs

A building block approach adopted for the certification of the aft, composite central fuselage of the Super Puma MK2 helicopter is described. Emphasis is placed on the qualification of the composite materials, the inclusion of environmental effects, and the damage tolerance. It is concluded that this approach allows for a number of technological progresses in the material and material behavior field as well as related technologies in an industrial environment. O.G.

A92-14448
COMPOSITE GEARBOX HOUSING
GEOFFREY C. R. DAVIS (Sikorsky Aircraft, Stratford, CT) AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Paper. 12 p.

The design to cost, life cycle costs, and supportability requirements for the next generation of aircraft demand the use of new materials, designs, and manufacturing processes. To address these requirements for helicopter main transmission housings, a trade study was performed. This study outlined the most economic material and process combinations which met the engineering criteria of light weight, high stiffness, corrosion and environmental resistance, and elevated temperature performance. Detailed follow-up work was performed to develop the two most promising manufacturing material/process combinations for housings: Injection Molded Graphic Reinforced Thermoplastic and Resin Transfer Molded (RTM) Thermoset Composites. A representative RTM development housing was fabricated and evaluated for the Advanced Rotorcraft Transmission (ART) program. Author

A92-14452* Sikorsky Aircraft, Stratford, CT.
MANUFACTURING TECHNIQUES - SPLIT TORQUE PATH HELICOPTER TRANSMISSION
GEORGE D. MITCHELL, JR. (Sikorsky Aircraft, Stratford, CT) AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Paper. 14 p. Research supported by U.S. Army. refs
(Contract NAS3-25423)

A description of the manufacturing techniques, capital equipment, tooling plan, and assembly methods necessary to manufacture the split torque path gearbox is presented. This transmission was designed and built for the advanced rotorcraft transmission program of the U.S. Army and NASA. Consideration is given to the engineering technology advancements along with a description of the integrated product development team process. R.E.P.

A92-14453
BEARINGLESS MAIN ROTOR SYSTEM COMPOSITE COMPONENT FABRICATION TECHNIQUES
ALLEN J. MCINTIRE (Sikorsky Aircraft, Stratford, CT) AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Paper. 7 p.

An in-depth bearingless main rotor rotorhead design producibility trade study was performed to evaluate a five spoked integral flexbeam main rotor hub, compared to one made up of five individual flex beams. This evaluation indicated that the manufacturing cost of both configurations is the same, whereas the integral design provides a significant weight reduction. The tooling and manufacturing concepts that were investigated are outlined, and the risk reduction work performed in determining the feasibility of these concepts is described. R.E.P.

A92-14455
MAIN CONCEPTS OF PROVIDING THE STATIC/FATIGUE STRENGTH OF HELICOPTERS IN THE USSR
A. F. SELIKHOV (Tsentral'nyi Aerogidrodinamicheskii Institut, Zhukovsky, USSR) AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Paper. 33 p. refs

Procedures adopted in the USSR for ensuring the static/fatigue strength of the primary structures of helicopters are briefly reviewed. The discussion covers provisions for extending the flight vehicle life cycle, design requirements, procedures for testing experimental and commercial helicopters, and safety margins that are applied to flight test results. Attention is also given to feedback mechanisms incorporated into the existing system of static/fatigue strength assurance. V.L.

A92-14456
DESIGN AND FLIGHT TEST EVALUATION OF THE FANTAIL ANTITORQUE SYSTEM
RENE A. DESJARDINS, ANDREW N. BERTOLAZZI (Boeing Defense and Space Group, Helicopters Div., Philadelphia, PA), and WILLIAM L. NOEHREN (Sikorsky Aircraft, Stratford, CT) AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Paper. 11 p. refs

A Fantail flight demonstrator program aimed at validating Light Helicopter (LH) performance is described. Test results indicate that the H-76 Fantail aircraft has demonstrated a yaw control performance that exceeds the capability of all other helicopters in the current Army fleet. Maximum performance points attained include sideward flight to 70 knots, 180-degree hover turns to a stop in 4 seconds, 360-degree hover turns to a stop in 5.5 seconds, and 90-degree snapturns at speeds up to 80 knots. It is concluded that the demonstrator has met all of the First Team's test objectives and provides confirmation of its LH design. O.G.

A92-15326
AIRCRAFT DESIGN EXPERIENCE
S. KIKUHARA (Japan Society for Aeronautical and Space Sciences, Journal, vol. 39, Aug. 1991, p. 379-387) Chinese Journal of Aeronautics (ISSN 1000-9361), vol. 4, May 1991, p. 87-98. Translation. Previously cited in issue 24, p. 4204, Accession no. A91-55451.
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A92-15334
STRATOSPHERIC LIGHTER-THAN-AIR POWERED PLATFORM
M. ONDA (MITI, Mechanical Engineering Laboratory, Tsukuba, Japan) Chinese Journal of Aeronautics (ISSN 1000-9361), vol. 4, May 1991, p. 156-162. refs
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A feasibility study has been carried out on a high altitude (20 km) superpressured PLTA(powered lighter-than-air) platform, which has a long service life and larger payload than that of a large artificial satellite. This PLTA platform has an electric propulsion system to cope with wind flow for position keeping and its thruster is driven by solar power acquired through solar cells. Solar energy is to be stored for night use in regenerative fuel cells. The study is focused on energy balance and hull structure analysis of the platform. This platform is particularly capable of conducting high

resolution remote sensing and telecommunications relay. This platform can replace a number of ground-based telecommunications relay facilities and can guarantee reasonable radio frequency intensity enough to secure good telecommunications quality. The altitude where the platform resides is the least windy area in the lower stratosphere at a height from which one can have a direct line of sight on the ground within a 1,000 km diameter range. The platform can also be useful to chase typhoons and to observe them from their births in the tropical regions. Author

A92-15341
THE CANARD-WING INTERFERENCE AND STALL SAFETY OF LIGHT CANARD AIRCRAFT
ZHENZHU BAI and XIAOBIN XIE (Nanjing Aeronautical Institute, People's Republic of China) Chinese Journal of Aeronautics (ISSN 1000-9361), vol. 4, May 1991, p. 226-234. refs
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Canard-wing interference is examined based on wind tunnel tests, and the development of aerodynamic configurations of the AD-100/200 (light canard aircraft designed by the NAI) is reviewed. The safety against stall of a canard is evaluated on the basis of flight testing. The rule 'canard stall first' is introduced as an effective measure for improving stall safety, although the rule may threaten flight safety at low altitude. What a designer can do to eliminate this threat is also discussed. L.M.

A92-15342
DYNAMIC BEHAVIOR ANALYSIS FOR LANDING-GEAR WITH DIFFERENT TYPES OF DUAL-CHAMBER SHOCK-STRUTS
HONG NIE, XIN QIAO (Nanjing Aeronautical Institute, People's Republic of China), ZEJUN GAO (Chengdu Aircraft Corp., People's Republic of China), and LANQIN ZHOU (Landing Gear Factory, Yangxian, People's Republic of China) Chinese Journal of Aeronautics (ISSN 1000-9361), vol. 4, May 1991, p. 235-244. refs
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In this paper three types of dual-chamber shock-struts are considered in dynamic analyses of landing-gear behavior during impact and taxi. Their dynamic characteristics are compared with each other according to calculation results, and some conclusions are presented. It is very helpful for selecting a suitable type of dual-chamber shock-strut in landing-gear design. Author

A92-15602
SUBSONIC PROPULSION SYSTEM INSTALLATION ANALYSIS AND OPTIMIZATION
J. L. COLEHOUR, B. W. FARQUHAR, J. E. GENGLER, and T. A. REYHNER (Boeing Commercial Airplane Group, Seattle, WA) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. refs
(ASME PAPER 91-GT-167)

CFD now allows analysis of propulsion system installations on subsonic transports to the extent that many configuration decisions can be made without testing. The methods discussed here utilize low-cost potential flow methods to predict inviscid flow characteristics and utility methods to model geometry, generate computational mesh, estimate wave drag, and perturb geometry in ways that promise improved performance. Jet plume effects are included in the potential flow analysis by means of a plume simulation method. Wave drag predictions yield levels of drag that are consistent with wind tunnel results, and, through contour optimization, wave drag for a trial propulsion installation geometry was reduced by about 50 percent. Through the use of methods such as these, many propulsion system installation design decisions can be made by analysis relatively quickly, which should lead to reduced design development time and cost. Author

A92-15705
AN INVESTIGATION OF TWO COOLING TECHNOLOGIES AS APPLIED TO A DISTRIBUTED PROPULSION CONTROL ARCHITECTURE
CARL F. WEISS (Pratt and Whitney Group, West Palm Beach, FL) and TYLER G. COX ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 3 p.
(ASME PAPER 91-GT-341)

The use of vortex tubes and thermoelectric coolers were investigated in a study of cooling the remote electronics of a future distributed propulsion control architecture. Vortex tubes operating off environmental control system air accommodate the diverse cooling requirements of new applications, but the system weight penalty from tubes and plumbing may be unacceptable (depending on the application). Thermoelectric elements combined with a fuel heat sink could be used under select conditions, but only up to fuel temperature of 230 C for the near future. Author

A92-15726
OPTIMAL THERMAL MANAGEMENT SYSTEM FOR HALE UAV
R. S. PATEL (U.S. Navy, Naval Air Development Center, Warminster, PA) and C. E. LENTS (Sundstrand Corp., Advanced Technology Group, Rockford, IL) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. refs
(ASME PAPER 91-GT-396)

This paper discusses an optimal thermal management system for a High Altitude Long Endurance Unmanned Air vehicle, examining several configurations to reject waste heat from the vehicle's propulsion engine cooling system as well as the avionic cooling system, and identifies a configuration which has minimum impact on aircraft endurance, component reliability, and development risks. The optimization process incorporates two basic heat rejection approaches: (1) a conventional approach which rejects cooling system waste heat to the atmosphere, and (2) a waste heat recovery approach which converts a portion of the waste heat into electricity to power avionics. Both concepts were optimized for three types of propulsion engines: spark ignition piston engines, rotary engines, and diesel engines. Author

A92-16051
1990 REPORT TO THE AEROSPACE PROFESSION; SOCIETY OF EXPERIMENTAL TEST PILOTS, SYMPOSIUM, 34TH, BEVERLY HILLS, CA, SEPT. 27-29, 1990, PROCEEDINGS
Lancaster, CA, Society of Experimental Test Pilots, 1990, 230 p. For individual items see A92-16052 to A92-16064.
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The present conference discusses the high-alpha X-29 aircraft, the F-15 STOL/Maneuvering Technology Demonstrator's thrust vectoring and reversing, F-14/F110 engine integration, V-22 flight testing, the USAF NASP program, the ARES light attack aircraft, F-117A flight testing, and YF-23A preliminary flight test results. Also discussed are development status reports for the JAS 39 Gripen fighter and the EH-101 helicopter, as well as development and flight test histories for the MiG 29 fighter prototype and the F5D Skylancer follow-on to the F4D Skyray. O.C.

A92-16052* National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
X-29 HIGH ANGLE OF ATTACK
STEPHEN D. ISHMAEL, ROGERS E. SMITH (NASA, Flight Research Center, Edwards, CA), DANA D. PURIFOY (USAF, Flight Test Center, Edwards AFB, CA), and RODNEY K. WOMER (Grumman Corp., Point Mugu, CA) IN: 1990 report to the aerospace profession; Society of Experimental Test Pilots, Symposium, 34th, Beverly Hills, CA, Sept. 27-29, 1990, Proceedings. Lancaster, CA, Society of Experimental Test Pilots, 1990, p. 5-14.
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Flight test program highlights are discussed for the X-29 high angle-of-attack (AOA) aircraft. The AOA envelope extended from 10 to 66 deg; the X-29 exhibited precise pitch control, allowing AOA to be maintained within 1 deg during stabilized points as well as permitting rapid recoveries from all AOAs. Attention is given to controllability degradation above 40-deg AOA due to asymmetric yawing moments. The use of this aircraft as a

fundamental research tool which complements analytical methods is powerfully justified by the obviation of scaling effects. O.C.

A92-16053
HELICOPTER NVG TESTING IN THE UNITED KINGDOM
RANDALL W. CASON (U.S. Army, Washington, DC) and MICHAEL R. SWALES (Aeroplane and Armament Experimental Establishment, Boscombe Down, England) IN: 1990 report to the aerospace profession; Society of Experimental Test Pilots, Symposium, 34th, Beverly Hills, CA, Sept. 27-29, 1990, Proceedings. Lancaster, CA, Society of Experimental Test Pilots, 1990, p. 15-29.

A development status evaluation is presented of helicopter night vision goggle (NVG) tests conducted to date in Britain, giving attention to NVG cockpit-compatibility issues in various operational environments that are important to the maximization of flight safety. Accounts are given of NVG test experience obtained with simulated battlefields, adverse weather, mountain flying, maritime operations, flight over snow-covered surfaces, and TOW antitank missile firings. Cockpit-lighting environments allowing easy identification of instrument readings and switch positions by the pilot are of critical importance. O.C.

A92-16054
F-15 STOL/MANEUVERING TECHNOLOGY DEMONSTRATOR. PHASE III - THRUST VECTORING, REVERSING AND STOL OPERATION
LAURENCE A. WALKER (McDonnell Aircraft Co., Saint Louis, MO) and ERWIN B. JENSCHKE, JR. (USAF, Washington, DC) IN: 1990 report to the aerospace profession; Society of Experimental Test Pilots, Symposium, 34th, Beverly Hills, CA, Sept. 27-29, 1990, Proceedings. Lancaster, CA, Society of Experimental Test Pilots, 1990, p. 30-49.

The highly modified NF-15B aircraft used by the STOL/Maneuvering Technology Demonstration program employs a four-channel FBW flight and propulsion control system, in conjunction with 2D thrust-vectoring/thrust-reversing nozzles, close-coupled canards, rough-field landing gear, and autonomous landing guidance. Attention is given to this aircraft's pitch vectoring at high angle-of-attack, in-flight thrust reversing, STOL operation, and short-landing ('SLAND') control mode. SLAND operations reduce landing roll lengths by 65 percent. O.C.

A92-16055
F-14/F110 ENGINE INTEGRATION
JENNINGS R. BRYANT, JR. (U.S. Navy, Naval Air Test Center, Patuxent River, MD) IN: 1990 report to the aerospace profession; Society of Experimental Test Pilots, Symposium, 34th, Beverly Hills, CA, Sept. 27-29, 1990, Proceedings. Lancaster, CA, Society of Experimental Test Pilots, 1990, p. 53-66.

A full-scale demonstration (FSD) program was conducted for an F110 turbofan engine-retrofitted F-14A aircraft en route to the development of the similarly-engined F-14D. The retrofit-engine integration effort entailed major redesigns of the engine thrust mounts, augmentor, and engine gearbox. The FSD gave attention to F110 combustor flameout, transonic buffet, airflow-matching, and hammershock stalling characteristics; also studied were afterburner vapor trails, screech, and liner burnthrough phenomena. In-flight windmill airstarts were demonstrated. O.C.

A92-16056
V-22 FLIGHT TEST
ROY C. HOPKINS (Bell Helicopter Textron, Inc., Fort Worth, TX) and RICHARD BALZER (Boeing Co., Helicopters Div., Philadelphia, PA) IN: 1990 report to the aerospace profession; Society of Experimental Test Pilots, Symposium, 34th, Beverly Hills, CA, Sept. 27-29, 1990, Proceedings. Lancaster, CA, Society of Experimental Test Pilots, 1990, p. 67-81.

The V-22 tilt-rotor VTOL aircraft whose flight test results are presented employs both a digital triplex FBW primary flight control system (PFCS) with an analog backup system, and an automatic flight control system; only the PFCS has been tested to date. PFCS sensitivity and damping characteristics have been found to be adequate in all axes. STOL takeoffs using 60-deg nacelle tilt have been performed, and are found to be very impressive in both acceleration and Level 1 handling. Level 2 handling qualities have been demonstrated as well. O.C.

A92-16058
JAS 39 GRIPEN PROGRESS REPORT
ARNE LINDHOLM (Saab-Scania, AB, Linkoping, Sweden) IN: 1990 report to the aerospace profession; Society of Experimental Test Pilots, Symposium, 34th, Beverly Hills, CA, Sept. 27-29, 1990, Proceedings. Lancaster, CA, Society of Experimental Test Pilots, 1990, p. 109-116.

The JAS 39 Gripen is a multirole lightweight combat aircraft capable of takeoff and landing operations on ordinary roads. The Gripen employs a full-authority triplex flight control digital system with triplex analog backup. Attention is given to the nature of the accident that occurred during the test flight aircraft's sixth landing, and the lessons derived from it for subsequent flight tests. Flight test functions have been incorporated by the flight control system in order to ensure the reproduction of steps, doublets, and frequency-sweeps during flights. O.C.

A92-16060
EH101 HELICOPTER DEVELOPMENT
C. W. HAGUE (Westland Helicopters, Ltd., Yeovil, England) IN: 1990 report to the aerospace profession; Society of Experimental Test Pilots, Symposium, 34th, Beverly Hills, CA, Sept. 27-29, 1990, Proceedings. Lancaster, CA, Society of Experimental Test Pilots, 1990, p. 134-140.

A single development program is being conducted so that both the military and civilian versions of the EH101 helicopter achieve simultaneous qualification process completion for certification. The program encompasses a rear-entry loading ramp-equipped variant for both civilian and military use. A total of 4000 flying hours are distributed among nine prototypes. Attention is given to the development of the primary flight displays, whose parameters are controlled by a cockpit central-console panel. A number of stabilizer configurations was tested to address a nose pitch-up problem encountered during transition to and from hover. O.C.

A92-16061
F-117A FLIGHT TEST PROGRAM
HAROLD C. FARLEY, JR. and RICHARD ABRAMS IN: 1990 report to the aerospace profession; Society of Experimental Test Pilots, Symposium, 34th, Beverly Hills, CA, Sept. 27-29, 1990, Proceedings. Lancaster, CA, Society of Experimental Test Pilots, 1990, p. 141-167. refs

An examination is conducted of the design challenges and flight test program results of the F-117A 'stealth fighter'. Since the F-117A represented such a major departure from conventional aerodynamic design, a major effort was made to reduce development risks through the incorporation of off-the-shelf powerplants, weapons, control systems, avionics, and cockpit components. The F-117A's flight control system, despite being of FBW type, has been designed to handle like an ordinary system without 'higher-order' effects. Flight tests explored angle of attack, flutter, engine and structure behavior, and icing. O.C.

A92-16063
YF-23A PRELIMINARY FLIGHT TEST RESULTS
PAUL METZ (Northrop Corp., Aircraft Div., Hawthorne, CA) IN: 1990 report to the aerospace profession; Society of Experimental Test Pilots, Symposium, 34th, Beverly Hills, CA, Sept. 27-29, 1990, Proceedings. Lancaster, CA, Society of Experimental Test Pilots, 1990, p. 205-217.

The Advanced Tactical Fighter Demonstration/Validation (ATF DEM/VAL) F-22 and F-23 prototypes were intended to minimize risk from the incorporation of as yet only partially mature technologies. Attention is presently given to the test pilot training and flight test programs instituted for the F-23A supersonic cruise/low observables ATF DEM/VAL. Three pilot-training resources were used to create the first flight environment: a fixed-base simulator, the Vehicle Management System Laboratory, and the Edwards AFB facility. O.C.

A92-16064
MIG-29 PROTOTYPE AND DEVELOPMENT FLIGHT TESTS - GENERAL OVERVIEW AND HIGH ANGLE OF ATTACK INVESTIGATION
VALERII E. MENITSKII (Mikoyan Design Bureau, USSR) IN: 1990 report to the aerospace profession; Society of Experimental Test Pilots, Symposium, 34th, Beverly Hills, CA, Sept. 27-29, 1990, Proceedings. Lancaster, CA, Society of Experimental Test Pilots, 1990, p. 218-221.
Copyright
A flight test program history is presented for the MiG-29 prototypes, which began in October, 1977. The program proceeded on the bases of the results from computer models, simulator investigations based on modeling results, the test of free-flight models, wind tunnel tests, and spin-recovery capability tests. Attention is given to the behavior encountered during MiG-29 spin behavior and high angle-of-attack testing, by comparison with the MiG-23. O.C.

A92-16622
MIRAGE 2000-5 - DASSAULT'S DELTA DESCRIBED
GILBERT SEDBON Flight International (ISSN 0015-3710), vol. 140, Nov. 20, 1991, p. 41-45.
Copyright
A review is presented of the major technical features incorporated in the Mirage 2000-5 fighter aircraft with the particular aspects influenced by the international market. Attention is given to details of this single-seat air-defense fighter (or two-seat trainer), including the FBW system, the powerplant, weights and dimensions, typical armament, and performance. R.E.P.

A92-16676
STATUS OF THE NH90 EUROPEAN HELICOPTER PROGRAM
J. P. BARTHELEMY, R. D. VON RETH (NH Industries, Aix-en-Provence, France), and G. BEZIAC (Aerospatiale, Marignane, France) Vertiflite (ISSN 0042-4455), vol. 37, Nov.-Dec. 1991, p. 69-79.
Copyright
The NH90 helicopter, which is jointly produced by France, Germany, Italy, and The Netherlands, appears in two variants: a tactical transport helicopter, and a naval helicopter for deployment aboard frigates. A composite fuselage design is employed which represents a 20 percent weight-saving relative to a metallic structure. Nuclear/biological/chemical weapons vulnerability and protection considerations were major design drivers; the fuselage rear section is contoured to permit the installation of a ramp for vehicle-embarkment. O.C.

A92-16802
MAXIMUM MASS ALLOWANCE TO JUSTIFY PASSENGER-CARRYING AIRCRAFT MODIFICATION [PREDEL'NYE IZDERZHKI MASSY, OBESPECHIVAIUSHCHIE TSELESOOBRAZNOST' MODIFIKATSII PASSAZHIRSKOGO SAMOLETA]
V. P. GOGOLIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1990, p. 8-11. In Russian. refs
Copyright
Calculations are made to determine the maximum permissible additional mass when designing passenger aircraft that can be modified to carry varying amounts of fuel for routes of different lengths. The problem is solved from the standpoint of early stages of design using fuel efficiency as the criterion. Preliminary estimates indicate that the realistic additional mass allowance can be approximately 2000 kg. V.L.

A92-16809
PROBLEM OF THE OPTIMAL CORRECTION OF A FLIGHT TEST PROGRAM FOR AN AIRCRAFT SYSTEM [K ZADACHE OPTIMAL'NOI KORREKTSII PROGRAMMY LETNYKH ISPYTANII AVIATSIONNOGO KOMPLEKSA]
V. A. TALYZIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1990, p. 33-38. In Russian. refs
Copyright
The problem of the optimal incorporation of additional tests into the existing flight test program for an aircraft system is formulated. The optimality criterion includes the cost and probability of the successful completion of the tests. The problem is formalized, reduced to a discrete programming problem with constraints, and then solved by using a successive optimization procedure. V.L.

A92-16833
COMPUTER-AIDED EQUIPMENT LAYOUT FOR THE FUSELAGE OF MANEUVERABLE AIRCRAFT [AVTOMATIZIROVANNAIA KOMPONOVKA OBORUDOVANIIA V FIUZELIAZHE MANEVRENNOGO SAMOLETA]
O. B. PASHCHENKO Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1990, p. 111-113. In Russian. refs
Copyright
A heuristic method for the synthesis of a layout scheme for the fuselage equipment of maneuverable aircraft is described which is based on formalized procedures commonly used in design practice. The heuristic layout design problem is solved using morphological analysis, and the design process is described in the form of a generalized algorithm. The method has been implemented in an interactive computer-aided design system. V.L.

A92-17093
DORNIER DO 328 - A START IN THE WORLD MARKET [DORNIER DO 328 - START AUF DEN WELTMARKT]
Luft- und Raumfahrt (ISSN 0173-6264), vol. 12, Sept.-Oct. 1991, p. 8-11, 14, 15. In German.
Copyright
The 30-seat regional commercial aircraft Dornier Do 328, now commencing test flights, is discussed. The aircraft design and use of materials is addressed, along with measures used to achieve noise reduction. The cooperation of various enterprises in the development of the aircraft is pointed out. C.D.

A92-17094
THE LONG-DISTANCE AIRBUS A340 - EUROPE'S LARGEST AIRCRAFT [LANGSTRECKEN-AIRBUS A340 - EUROPAS GROESSTES FLUGZEUG]
Luft- und Raumfahrt (ISSN 0173-6264), vol. 12, Sept.-Oct. 1991, p. 16-20. In German.
Copyright
The development of the Airbus A340 is reviewed. The evolution of the concept for this long-range aircraft and the selection of its wings, engine, and tail are addressed. The different versions of the aircraft are briefly described. C.D.

A92-17253
LIGHTNING PROTECTION FOR THE DORNIER 328
THOMAS THIELE Dornier Post (ISSN 0012-5563), no. 3, 1991, p. 70, 71.
Copyright
For the Do 328 commuter aircraft, a surface-zoning plan has been developed which characterizes lightning-strike loads, according to a statistical distribution of strike probabilities. This zoning plan is also informed by information concerning the distribution and/or position of electrical and electronic equipment and cabling. The lightning-protection system employed by the Do 328 represents an overall weight increase of 70-100 g/sq m. The different treatments used on fuselage, wing, and empennage are discussed. O.C.

A92-17254
INTERIOR NOISE REDUCTION PROGRAM FOR THE DORNIER 328
H. J. HACKSTEIN, INGO U. BORCHERS, PETER BARTELS, and CHRISTIAN WENIGWIESER *Dornier Post* (ISSN 0012-5563), no. 3, 1991, p. 72-74.
Copyright

The designers of the Do 328 commuter aircraft have undertaken to achieve a cabin noise level not exceeding 78 dB(A) at 75 percent of passenger seats. The process proceeded by identifying critical noise sources and noise transmission paths, followed by noise and vibration tests with components and systems for the optimization of noise insulators and dampers. Flight test verifications of the design modification measures taken have been obtained. O.C.

N92-11989 George Washington Univ., Washington, DC.
PRACTICAL INPUT OPTIMIZATION FOR AIRCRAFT PARAMETER ESTIMATION EXPERIMENTS Ph.D. Thesis
EUGENE ARCANGELO MORELLI 1991 175 p
Avail: Univ. Microfilms Order No. DA9123065

Mathematical models of aircraft dynamics typically contain quantities called parameters, which depend, in general, on the flight condition and the aircraft geometry. It is important to be able to estimate these parameters accurately from flight testing the aircraft. The object was to develop an algorithm for the design of practical, optimal flight test inputs for aircraft parameter estimation experiments. This algorithm must be capable of designing multiple input experiments for estimation of open loop model parameters from closed loop flight test data. A general, single pass technique was developed which allows global optimization of the flight test input design for parameter estimation using the principles of dynamic programming. Provision was made for practical constraints on the input form, including amplitude constraints, control system dynamics, and selected input frequency range exclusions. A new formulation is presented of the optimal input design problem along with a description of a new approach to the solution, and a summary of the characteristics of the algorithm, followed by three example applications of the new technique which shows the quality and expanded capabilities of the input design produced by the technique. Dissert. Abstr.

N92-11990# National Research Council of Canada, Ottawa (Ontario). Structures and Materials Lab.
TUTOR AFT FUSELAGE AND EMPENNAGE FULL-SCALE FATIGUE TEST: RESOLUTION OF HORIZONTAL STABILIZER INSTALLATION DIFFICULTIES
B. E. SHAVER and L. LEBLANC Nov. 1990 13 p
(Contract FE220787NRC01; IAR PROJ. 07332)
(NRC-LTR-ST-1804; CTN-91-60261) Copyright Avail: NTIS HC/MF A03

Difficulty was experienced during an attempt to install the horizontal stabilizer bar from one CT-114 Tutor aircraft to another. The difficulty was caused by a misalignment of approximately 0.018 inches between holes in the horizontal stabilizer rear attachment fitting and mating holes in the horizontal stabilizer main attachment brackets. This report describes the investigation of the dimensional discrepancy and the solution that was used. Due to time constraints it was decided that altering the rear attachment fitting assembly to match the main attachment brackets on the horizontal stabilizer would be relatively simple and have minimal effect on the load paths or local structure. The steel bushings pressed into the fitting were removed and replaced with eccentric bushings manufactured specifically to deal with the dimensional discrepancy of the components. Bushings were manufactured from the same material and to the same specifications as the original except for the .009 inch offset of the inner surface relative to the outer surface. After 30,000 simulated flight hours no difficulties have been encountered with the bushings or the surrounding structure. Horizontal stabilizers should not be considered totally interchangeable within the fleet. The use of excessive force to install horizontal stabilizer attachment bolts should be avoided since unseen damage may be incurred by the surrounding structure and unnecessary residual stresses may be induced which could alter the fatigue life of the structure. CISTI

N92-11991# National Research Council of Canada, Ottawa (Ontario). Inst. of Aerospace Research.
CORROSION AND YOUR AIRCRAFT
G. F. MARSTERS Jun. 1988 10 p
(NRC-30465; NAE-MISC-63; CTN-91-60290) Copyright Avail: NTIS HC/MF A02

This article provides information about the nature and effects of corrosion on metal aircraft structures. It is written with the pilot/operator in mind and avoids detailed engineering and scientific treatments of the subject. It is highly descriptive in nature and has as its objective the enhancement of safety through increased awareness of the problems which corrosion can cause. It includes examples and data which will alert operators to corrosion attack and help to avoid hazards through early detection and correction. Author (CISTI)

N92-11992*# Lockheed Engineering and Sciences Co., Hampton, VA.
A COMPARATIVE ANALYSIS OF XV-15 TILTROTOR HOVER TEST DATA AND WOPWOP PREDICTIONS INCORPORATING THE FOUNTAIN EFFECT
CHARLES K. RUTLEDGE, CHARLES D. COFFEN, and ALBERT R. GEORGE (Cornell Univ., Ithaca, NY.) 1991 20 p
(Contract NAS1-19000; NAG2-554)
(NASA-CR-189455; NAS 1.26:189455) Avail: NTIS HC/MF A03 CSCL 01C

Acoustic measurements from a hovering full scale XV-15 tilt rotor with the advanced technology blades are presented which show the directionality of fountain effect noise. Predicted acoustic directivity results are also presented which show agreement with the measured data. The aeroacoustic code, WOPWOP, was used in conjunction with a mathematical model which simulated the fountain recirculation aerodynamic effect on the rotor blade surface pressures. The predictions were used to identify the spike character in the measured data as fountain effect associated noise. The directivity of the fountain effect noise was observed to be dominant at the rear of the aircraft with increased intensities 45 degrees below the rotor disk planes. Author

N92-11993# Aeronautical Research Inst. of Sweden, Stockholm. Aerodynamics Dept.
PERFORMANCE IMPROVEMENTS AND FUEL COST SAVINGS DUE TO LEADING EDGE MODIFICATION OF A VINTAGE DELTA WING JET FIGHTER
SVEN-OLOF RIDDER Apr. 1991 29 p Original contains color illustrations
(Contract FMV-FFL-82260-89-262-73-001)
(FFA-TN-1991-22; ETN-91-90287) Avail: NTIS HC/MF A03

The improved aerodynamic efficiency of the aircraft J35 Draken resulting from simple leading edge modifications is evaluated. The study was carried out using earlier wind tunnel data and the actual data of installed thrust and fuel consumption of the jet engine. Improvements in important performance aspects comparable to what could have been achieved by installing a modern jet engine, but at a fraction (probably less than 5 pct.) of the cost switching to a new engine as achieved. A significant improvement in pitch and roll stability in relation to the characteristics of the original aircraft was also achieved. Apart from the obvious tactical value of upgrading the performance (range, maneuver and external load) there comes the added peacetime benefit of a 25 pct. fuel cost reduction for a given training program. ESA

N92-12534# Naval Air Development Center, Warminster, PA.
AI FOR RPVS, SENSOR DRIVEN AIRBORNE REPLANNER (SDAR), FOR A ROBOTIC AIRCRAFT SENSOR PLATFORM (RASP)
R. M. WILLIAMS and J. J. DAVIDSON *In* AGARD, Machine Intelligence for Aerospace Electronic Systems 6 p Sep. 1991

Copyright Avail: NTIS HC/MF A14; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The Robotic Aircraft Sensor Platform (RASP) simulation developed at the Naval Air Development Center in Warminster, PA. is described. A hardware and associated software architecture was developed to use on-board sensor information for high level artificial intelligence (AI) decision making. The decisions then direct the flight path of the aircraft and camera gimbal through complex environments. This project has produced a system architecture that breaks the bottleneck of flyable real time AI control systems. The work has transitioned into three new efforts: a flight test effort for the Unmanned Air Vehicle Joint Program Office; an investigation into the use of SDAR for novel systems of sensors and platforms such as the Tactical Imaging System, and a study of applying this technology to manned platforms to assist human operators. Author

N92-13053 Georgia Inst. of Tech., Atlanta.
A NUMERICAL SOLUTION OF IMPLICIT NONLINEAR EQUATIONS OF MOTION FOR ROTOR BLADES Ph.D. Thesis
YOUNG KIL KIM 1991 161 p
Avail: Univ. Microfilms Order No. DA9124530 CSCL 01/3

A comprehensive procedure for formulating nonlinear equations of motion implicitly is developed using a numerical treatment of the energies based on Hamilton's principle. This procedure is used to determine the aeroelastic response and aeroelastic stability characteristics of helicopter rotor blades in hover. The analysis is capable of handling initially curved and pretwisted rotor blades, which undergo large coupled extension, chordwise bending, flapwise bending, and torsion. The current development includes all higher order nonlinear structural terms in the equations of motion without using small deflection assumptions. Thus, the inconsistency of ordering schemes used in the previous works no longer exists. However, in order to express the equations in terms of displacements defined along the reference axis of the undeformed blade, the Euler-Bernoulli assumption is used to determine a transformation matrix between the undeformed position and the final deformed position. For the purpose of comparing the present implicit method with a comparable explicit formulation of the equations of motion, a simplified set of equations of motion are solved using a Galerkin type method. These procedures for the formulation of nonlinear solution method are coded and tested for the static deflection calculation of a very flexible beam and for the extensional deflection calculation of rotor blades in vacuum. Numerical results are also presented which show the steady and unsteady dynamic responses of hingeless rotor blades in hover. Finally, the results for an aeroelastic linear stability analysis of a cantilever rotor blade in hover are presented. It is concluded that the present method is a useful and accurate approach for the analysis of flexible nonrotating beams and rotor blades.
Dissert. Abstr.

N92-13054*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PLANFORM CURVATURE EFFECTS ON FLUTTER CHARACTERISTICS OF A WING WITH 56 DEG LEADING-EDGE SWEEP AND PANEL ASPECT RATIO OF 1.14
DONALD F. KELLER, MAYNARD C. SANDFORD, and THERESA L. PINKERTON (Illinois Univ., Urbana.) Washington Sep. 1991 46 p
(NASA-TP-3116; L-16858; NAS 1.60:3116) Avail: NTIS HC/MF A03 CSCL 01/3

An experimental and analytical investigation was initiated to determine the effects of planform curvature (curving the leading and trailing edges of a wing in the X-Y plane) on the transonic flutter characteristics of a series of three moderately swept wing models. Experimental flutter results were obtained in the Langley Transonic Dynamics Tunnel for Mach numbers from 0.60-1.00, with air as the test medium. The models were semispan cantilevered wings with a 3 percent biconvex airfoil and a panel aspect ratio of 1.14. The baseline model had straight leading and trailing edges (i.e., no planform curvature). The radii of curvature of the leading edges for these two models were 200 and 80 inches. The radii of curvature of the leading edges of the other two models were determined so that the root and tip chords were identical for all three models. Experimental results showed that flutter-speed index and flutter frequency ratio increased as planform curvature increase (radius of curvature of the leading edge was decreased) over the test range of Mach numbers. Analytical flutter results were calculated with a subsonic flutter-prediction program, and they agreed well with the experimental results. Author

N92-13055# Boeing Co., Seattle, WA.
DUAL MODE SHOCK ABSORBER AND METHOD Patent
STEVEN M. WARREN, inventor 6 Feb. 1990 42 p
(PATENT-1-265-541; INT-PATENT-CLASS-F16F-948; CTN-91-60232) Copyright Avail: Micromedia Ltd., Technical Information Centre, 165 Hotel de Ville, Place du Portage, Phase 2, Hull, Quebec J8X 3X2, Canada HC $4.00 CAN, MF $2.75 CAN

The subject of this invention is a dual mode shock absorber for use on aircraft. The shock absorber has a first mode of operation with a relatively high hydraulic orifice area that decreases during an initial compression, and a second mode of operation with a relatively small fixed orifice for dampening loads caused by relative extensions and compressions following the initial compression. This apparatus provides a new design approach for shock absorbers which is particularly well suited to the anticipated future requirements for military aircraft. The provision of two modes of load damping makes it possible to accomplish optimal absorption of landing impact energy and also to optimize the control of rough field taxi loads and aircraft motion during ground roll over damaged or semi-prepared runways. The system is highly reliable and automatically switches from landing mode to ground roll mode without human intervention. CISTI

N92-13056# National Research Council of Canada, Ottawa (Ontario). Inst. of Aerospace Research.
A PROPOSED COMPOSITE REPAIR METHODOLOGY FOR PRIMARY STRUCTURE
S. R. HALL, M. D. RAIZENNE, and D. L. SIMPSON 13 Jan. 1988 13 p
(NRC-LTR-ST-1658; CTN-91-60292) Avail: NTIS HC/MF A03

Advanced composite materials are used extensively in aircraft structures. One of the major problems that faces the operators of aircraft which use these materials, is that of structural repair. Composite structures require different repair techniques than do their metal counterparts. Presently, there is very little data available which permits composite structural repairs to be designed and evaluated. The databases and expertise which must be developed include basic materials data, analysis techniques which can be used to design and evaluate repair techniques, aircraft load zoning according to component criticality along with definition of the repairable damage that can occur in each zone, evaluation of the advantages and disadvantages of joining techniques which might be used in repair, development of nondestructive inspection techniques, identification of critical loads for composites, development of suitable coupons for the evaluation of repair techniques, identification of the type of build-up structure that can be used to design and evaluate test and analytical methods, and development of methods to define, repair, and test repairs on build-up structures. Methods to predict built-up structure repair response must be made, and means of testing correlation between test and analytical results must be developed. Valid repair methods should be compiled in a repair manual. CISTI

N92-13057*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FLAPPING INERTIA FOR SELECTED ROTOR BLADES
JOHN D. BERRY and MATTHEW J. MAY (Military Academy, West Point, NY.) Nov. 1991 60 p
(NASA-TM-104125; NAS 1.15:104125; AVSCOM-TR-91-B-019)
Avail: NTIS HC/MF A04 CSCL 01/3

Aerodynamics of helicopter rotor systems cannot be investigated without consideration for the dynamics of the rotor. One of the principal properties of the rotor which affects the rotor dynamics is the inertia of the rotor blade about its root attachment.

Previous aerodynamic investigation have been performed on rotor blades with a variety of planforms to determine the performance differences due to blade planform. The blades tested for this investigation have been tested on the U.S. Army 2 meter rotor test system (2MRTS) in the NASA Langley 14 by 22 foot subsonic tunnel for hover performance. This investigation was intended to provide fundamental information on the flapping inertia of five rotor blades with differing planforms. The inertia of the bare cuff and the cuff with a blade extension were also measured for comparison with the inertia of the blades. Inertia was determined using a swing testing technique, using the period of oscillation to determine the effective flapping inertia. The effect of damping in the swing test was measured and described. A comparison of the flapping inertials for rectangular and tapered planform blades of approximately the same mass showed the tapered blades to have a lower inertia, as expected. Author

N92-13058# Systems Control Technology, Inc., Arlington, VA.
HELICOPTER REJECTED TAKEOFF AIRSPACE REQUIREMENTS Final Report
EDWIN D. MCCONKEY, ROBERT J. HAWLEY, and ROBERT K. ANOLL Aug. 1991 52 p
(Contract DTFA01-87-C-00014)
(SCT-91RR-28; DOT/FAA/RD-90/7) Avail: NTIS HC/MF A04

An analysis is given of performance data for helicopters that are certified for one engine inoperative (OEI) performance. It relates rejected takeoff and OEI capability to airspace requirements for heliports intended to support Category A operations. The current FAA regulation defining protected airspace and the imaginary surfaces associated with heliports does not take into consideration emergency situations involving engine failures during takeoff and landing operations. That is, the air and ground space defined by this regulation provides no margin of safety for acceleration or stopping distance for a rejected takeoff. Furthermore, it defines departure paths (climbout angles) that are too steep for many helicopters' OEI climbout capability. Suggested here is a more flexible airspace system, based on helicopter performance, that should apply to protected airspace at heliports supporting Category A operations. Author

N92-13059# Systems Control Technology, Inc., Arlington, VA.
ROTORCRAFT ACCELERATION AND CLIMB PERFORMANCE MODEL Final Report
ROBERT K. ANOLL and EDWIN D. MCCONKEY Aug. 1991 47 p
(Contract DTFA01-87-C-00014)
(SCT-90RR-30; DOT/FAA/RD-90/6) Avail: NTIS HC/MF A03

The methodology is described used in developing the helicopter departure profiles. Each step involved in creating the profiles is examined. In particular, the Helicopter Departure Profile (HEDPRO) program is described in detail. This program converts helicopter performance data and departure procedures into departure profile data. The first step in developing profiles was to identify the departure procedures recommended by the manufacturers. Additionally, a safe confined area departure procedure needed to be developed. Next, climb and acceleration performance data specific to each helicopter and atmospheric condition was generated. This required extensive data to be collected for each helicopter. This data was then used in the Helicopter Sizing and Performance Computer Program (HESCOMP) developed to compute helicopter performance data. The last two steps were to compute and graph the profiles. HEDPRO was developed specifically for this project to compute the departure paths by determining the height/distance points of the path from the helipad. These points were then graphed to develop the final product. This methodology is described in sufficient detail so as to be valuable aid should other helicopter departure profiles need to be determined. Author

N92-13060# Systems Control Technology, Inc., Arlington, VA.
HELICOPTER PHYSICAL AND PERFORMANCE DATA Final Report
EDWIN D. MCCONKEY, ROBERT K. ANOLL, MARGARET B. RENTON, and JAMES YOUNG Aug. 1991 196 p
(Contract DTFA01-87-C-00014)
(SCT-91RR-27; DOT/FAA/RD-90/3) Avail: NTIS HC/MF A09

A determination of physical and performance data for 8 civil helicopters was made. The used helicopters were chosen to exhibit a wide range of characteristics representative of the current civil fleet. Flight manual data as well as certification, flight test, and computer generated performance data were used to complete the study. Approach and departure profiles were developed for several gross weights and ambient conditions and translated into graphs. A menu-driven database was designed to provide easy access to the data. The airspace required for approaches is dependent upon pilot skill and desired approach slope. Pilots can fly approaches steeper than the current standard 8:1 surface if required though pilot workload tends to increase and comfort levels tend to decrease. The airspace required for departures is a function of aircraft performance and ambient conditions. Author

N92-13061# Army Lab. Command, Watertown, MA. Material Technology Lab.
FAILURE ANALYSIS OF THE APACHE MIXER PIVOT SUPPORT Final Report
VICTOR K. CHAMPAGNE, JR., GARY WECHSLER, MARC S. PEPI, and KIRIT J. BHANSALI Jul. 1991 50 p
(AD-A240858; MTL-TR-91-25) Avail: NTIS HC/MF A03 CSCL 01/3

This report discusses a failure analysis of a mixer pivot support located on the AH-64 Apache Helicopter. The component was found to be broken in two pieces during an inspection. Visual inspection of the failed part revealed significant wear on surfaces that contacted the bushing and areas at the machined radius where the cadmium coating had been damaged allowing corrosion pitting to occur. Light optical microscopy showed that the crack origin was located at the machined radius within a region that was severely pitted. The hardness, chemistry, and microstructure of the electroslag remelted (ESR) 4340 steel used to fabricate the component conformed to required specifications and no apparent manufacturing defects were found. Electron microscopy showed that most of the fracture surface failed in an intergranular fashion with the exception of a shear lip zone which exhibited a dimpled morphology. The failure was set into action by hydrogen charging as a result of corrosion and was aggravated by the stress concentration effects of pitting at the radius and the high notch sensitivity of the material. Energy dispersive spectroscopy (EDS) determined that deposits of sand, corrosion, and salts were found within the pits. The failure mechanism was hydrogen assisted and was most likely a combination of stress corrosion cracking and corrosion fatigue. GRA

N92-13062# Air Force Systems Command, Wright-Patterson AFB, OH. Foreign Technology Div.
CHINA'S FIRST VARIABLE STABILITY AIRCRAFT: THE BW-1-GETS ITS PRE-ACCEPTANCE FLIGHT TESTS
YUAN DONG and JIAN YU 11 Sep. 1991 8 p Transl. into ENGLISH from Guoji Hangkong (China), no. 2, 1990 p 13
(AD-A240941; FTD-ID(RS)T-0460-91) Avail: NTIS HC/MF A02 CSCL 01/3

The BW-1 variable stability aircraft, which our country designed on its own and refitted, is a research test plane for simulating aerial flight. The refit was completed in March of 1988. In November of the same year, it went through its initial flight technology review. Late in September of 1989, pre-acceptance flight tests on the aircraft were completed. Once this was done, our nation's aviation industry added yet another important type of means for scientific research. GRA

N92-13063# North Carolina Agricultural and Technical State Univ., Greensboro.
BEHAVIOR OF AIRCRAFT TIRE COUPONS UNDER VARIOUS LOADING CONDITIONS Final Report, Sep. 1987 - Dec. 1990
V. S. AVVA, D. M. PAI, and R. L. SADLER Oct. 1991 146 p
(Contract F33615-87-C-3413)

(AD-A241416; WL-TR-91-3086) Avail: NTIS HC/MF A07 CSCL 01/3

The aircraft tire is a complex composite structure containing reinforcing nylon cords in a rubber matrix. It experiences a very complex loading during usage. There are inflation induced stresses as well as the centrifugal and flexural stresses induced by rolling. The material is exposed to cyclic thermal loading from heat generated by distortion and braking. All of these influence the useful life and performance of the tire. The tire designer needs to have an understanding of the constitutive properties of the aircraft tire and the influence of environment and loading on those properties. In this study, unused aircraft tires were cut open and specimens extracted to test for constitutive properties and a very important mechanical property called peel strength. The procedure for extracting the coupons, the fixturing and the simulated loading conditions used in the laboratory are discussed. Three kinds of peel test configurations were compared in a baseline study. The best configuration was then used to test conditioned coupons. The results and statistical analysis of these tests are presented. GRA

N92-13064*# PRC Systems Services Co., Edwards, CA.
AN AIRCRAFT MODEL FOR THE AIAA CONTROLS DESIGN CHALLENGE
RANDAL W. BRUMBAUGH Dec. 1991 17 p Presented at the AIAA GNC Conference, New Orleans, LA, 12 Aug. 1991 Previously announced in IAA as A91-49779
(Contract NAS2-12722)
(NASA-CR-186019; H-1777; NAS 1.26:186019; AIAA-91-2631)
Avail: NTIS HC/MF A03 CSCL 01/3

A generic, state-of-the-art, high-performance aircraft model, including detailed, full-envelope, nonlinear aerodynamics, and full-envelope thrust and first-order engine response data is described. While this model was primarily developed Controls Design Challenge, the availability of such a model provides a common focus for research in aeronautical control theory and methodology. An implementation of this model using the FORTRAN computer language, associated routines furnished with the aircraft model, and techniques for interfacing these routines to external procedures is also described. Figures showing vehicle geometry, surfaces, and sign conventions are included. Author

N92-13842*# North Carolina State Univ., Raleigh. Dept. of Mechanical and Aerospace Engineering.
FORMULATION OF THE LINEAR MODEL FROM THE NONLINEAR SIMULATION FOR THE F18 HARV
CHARLES E. HALL, JR. *In* Old Dominion Univ., NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1991 p 115-116 Sep. 1991
Avail: NTIS HC/MF A12 CSCL 01/3

The F-18 HARV is a modified F-18 Aircraft which is capable of flying in the post-stall regime in order to achieve superagility. The onset of aerodynamic stall, and continued into the post-stall region, is characterized by nonlinearities in the aerodynamic coefficients. These aerodynamic coefficients are not expressed as analytic functions, but rather in the form of tabular data. The nonlinearities in the aerodynamic coefficients yield a nonlinear model of the aircraft's dynamics. Nonlinear system theory has made many advances, but this area is not sufficiently developed to allow its application to this problem, since many of the theorems are existance theorems and that the systems are composed of analytic functions. Thus, the feedback matrices and the state estimators are obtained from linear system theory techniques. It is important, in order to obtain the correct feedback matrices and state estimators, that the linear description of the nonlinear flight dynamics be as accurate as possible. A nonlinear simulation is run under the Advanced Continuous Simulation Language (ACSL). The ACSL simulation uses FORTRAN subroutines to interface to the look-up tables for the aerodynamic data. ACSL has commands to form the linear representation for the system. Other aspects of this investigation are discussed. Author

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A92-13699
TOMORROW'S COCKPIT DISPLAYS
A. C. B. SINGER and I. W. MCCLELLAND (Royal Aerospace Establishment, Bedford, England) Aerospace (UK) (ISSN 0305-0831), vol. 18, Nov. 1991, p. 12-14.
Copyright

Research being done to develop the cockpit displays of tomorrow is discussed. The elements of advanced displays are described, and emphasis is given to 4D descent profiles and clearances. C.D.

A92-14350
RADAR DETECTION ANALYSIS OF ROTOR SYSTEMS (RADARS)
TERRY L. GIBSON (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 343-349. refs
Copyright

The strongly fluctuating radar signatures associated with the main rotor of helicopters significantly affects detectability by radar; an accurate evaluation of such detectability characteristics entails the inclusion of rotor dynamics in signature formulation and in the modeling of the procedure through which a radar receiver processes the main rotor signature component. The RADARS methodology, by which the fluctuating signature of a rotor system can be transformed into an effective subset of nonfluctuating signatures, has been developed and incorporated by a radar-detectability computer model. O.C.

A92-14378
FLIGHT TESTING THE AVIONICS SYSTEM OF THE V-22 OSPREY
KENNETH P. KATZ (Boeing Defense and Space Group, Helicopters Div., Philadelphia, PA) and RICHARD G. POULIN (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 705-719. refs
Copyright

The flight testing of the integrated digital avionics system of the V-22 Osprey tiltrotor aircraft is described. The major topics under consideration include the role of flight testing in the avionics development process, test techniques, avionics data acquisition and processing, and flight test results. It is concluded that the avionics system is suitable for conducting the V-22 mission. The most sophisticated avionics subsystems and functions (CMS, data processing, subsystem management, and central integrated checkout), have been successfully demonstrated. O.G.

A92-14402
FUNCTIONALLY INTEGRATED AIRCRAFT INSTRUMENTATION FOR THE NEXT GENERATION COMMERCIAL HELICOPTER
DOUG GEIST (McDonnell Douglas Helicopter Co., Mesa, AZ) and ZOLTAN FRIED (Canadian Marconi Co., Kanata, Canada) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 1057-1065.
Copyright

An Integrated Instrumentation Display System (IIDS) was designed to meet the aircraft instrumentation requirements of FAR, Part 27, for certification of commercial light helicopters. Criteria were defined that would allow an assessment of selected functions for integration into one unit. The goal was to provide a compact instrumentation system to monitor and display the performance of various aircraft subsystems. An aircraft subsystem monitoring

feature provides a means to acquire knowledge of the health of the aircraft subsystems. Engine performance can be monitored in real-time, which allows aircraft operators to better schedule repair/overhaul activities. Also, maintenance personnel can transfer collection of aircraft operational information to a ground-based computer for determining trending and maintenance actions. Vibration monitoring is provided to the helicopter user with a simple and convenient means of acquiring the information needed to minimize vibration caused by mass and aerodynamic imbalance in the rotor and NOTAR fan system. Author

A92-16057
THE FLIGHT TEST PILOT'S DISPLAY - A CRT SYSTEM FOR TEST MANEUVERS
BRUCE J. HINDS and B. L. SCHOFIELD (Northrop Corp., Los Angeles, CA) IN: 1990 report to the aerospace profession; Society of Experimental Test Pilots, Symposium, 34th, Beverly Hills, CA, Sept. 27-29, 1990, Proceedings. Lancaster, CA, Society of Experimental Test Pilots, 1990, p. 82-106. refs
Copyright

An account is given of the features and performance advantages of a CRT-based flight test pilot display (FTPD) system for controlling test maneuvers. The objective of the display was to bring aircraft state and maneuver trend information into a single display to facilitate a pilot's control of test conditions; this minimizes the need for maneuver repetition and improves data quality through superior maneuver-metrics control. This FTPD system has been successfully employed during flight tests of the B-2 bomber; qualitatively, it has been found to double test efficiency by allowing more rapid test setups and requiring fewer maneuver repetitions. O.C.

A92-16148
CONCEPT FOR FUTURE COCKPITS [CONCEPT DE COCKPITS FUTURS]
JEAN-NOEL PERBET, JEAN-JACQUES FAVOT, and BRUNO BARBIER (Sextant Avionique, Saint-Medard-en-Jalles, France) L'Onde Electrique (ISSN 0030-2430), vol. 71, Nov.-Dec. 1991, p. 57-60. In French. refs
Copyright

It is noted that future display devices will use multimedia systems allowing a multimode dialogue between man and the system. The concept of a large interactive display as applied to future cockpits is described. Attention is given to experiments on man-machine interaction and preliminary results of multimode dialogue. Experimental results indicate that an analysis of man-system interactions is necessary in order to create an optimal interface of multimode dialogue. L.M.

N92-11994*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
DEVELOPMENT OF A PNEUMATIC HIGH-ANGLE-OF-ATTACK FLUSH AIRDATA SENSING (HI-FADS) SYSTEM
STEPHEN A. WHITMORE Nov. 1991 28 p Presented at the SAE Aerotech 1991 Conference, Long Beach, CA, 23-26 Sep. 1991
(NASA-TM-104241; H-1766; NAS 1.15:104241) Avail: NTIS HC/MF A03 CSCL 01D

A nonintrusive high-angle-of-attack flush airdata sensing system was installed and flight tested in the F-18 High Alpha Research Vehicle. This system consists of a matrix of 25 pressure orifices arranged in concentric circles on the nose of the vehicle to determine angles of attack and sideslip, Mach number, and pressure altitude. During the course of the flight tests, it was determined that satisfactory results could be achieved using a subset of just nine ports. Author

N92-12531# Wright Lab., Wright-Patterson AFB, OH.
PILOT'S ASSOCIATE: EVOLUTION OF A FUNCTIONAL PROTOTYPE
CARL S. LIZZA, SHEILA B. BANKS, and MICHAEL A. WHELAN *In* AGARD, Machine Intelligence for Aerospace Electronic Systems 12 p Sep. 1991
Copyright Avail: NTIS HC/MF A14; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The Pilot's Associate Program has completed its first phase of functional development which included two significant program milestones. The early successful development of complex, knowledge based, decision aiding systems allowed the program to shift focus to a more near term, embedded avionics application of the technology. This change in philosophy forced an evolution away from a program designed to explore artificial intelligence without processing bounds, towards a more consistent with, and constrained by, the realities of an avionics processing architecture of an actual aircraft. One of the developmental approaches is focused on, the technical progress made through this phase of the program, and the accomplishments and disappointments with the design approach. Lastly, a brief look into the lessons learned as artificial intelligence technology was applied to a dynamic and complicated domain is presented. Author

N92-12536# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Military Aircraft Div.
EXPERT SYSTEM FOR THE TORNADO GROUND-BASED CHECK-OUT SYSTEM
J. FEY, J. MARANGOS, M. MERX, and W. MANSEL *In* AGARD, Machine Intelligence for Aerospace Electronic Systems 5 p Sep. 1991
Copyright Avail: NTIS HC/MF A14; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

A technology demonstrator, supporting the TORNADO check-out system for aircraft was developed and tested. The expert system, called TORRES (TORNADO Radar Readiness Expert System), supports debriefing staff with various levels of experience. The scope of the error detection encompasses the TORNADO Terrain Following and Ground Mapping Radar system down to the module level. The main task of TORRES is the identification and isolation of errors that occurred during the previous flight. The expert system is also able to exclude errors that were generated by other systems capable of changing the state of the radar system and isolate the cause. Other influences, like EMC, exceeding avionic systems acceleration limits, and weather effects are taken under consideration and reported. If an error run is left without an associated case, special test runs are suggested. An explanation facility generates detailed debriefing reports. Author

N92-12539# Wright Lab., Wright-Patterson AFB, OH.
INTEGRATED COMMUNICATIONS, NAVIGATION, IDENTIFICATION, AVIONICS (ICNIA) EXPERT SYSTEM FOR FAULT TOLERANT AVIONICS
MARK E. MINGES *In* AGARD, Machine Intelligence for Aerospace Electronic Systems 15 p Sep. 1991
Copyright Avail: NTIS HC/MF A14; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Embedded avionic systems for aircraft are becoming increasingly more complex. Very High Speed Integrated Circuits (VHSIC) and semi-custom devices are used to gain many-fold increases in processing power and capability. Mission and operational requirements dictate a high availability and fault detection capability defined quantitatively as 98 percent detection of all faults and isolation of 90 percent of those faults to a line replaceable module (LRM), or 95 percent of the faults to two LRM's. The Integrated Communications, Navigation, Identification Avionics (ICNIA) Program utilizes a module maintenance node (MN) which aids high speed testing of the LRM, and gives the ability to isolate the fault(s) to one or more modules. The MN uses the concepts of set scan design, pseudo-random test vector generation, output response compression, and separate set scan loops to test the small scale integration-medium scale integration logic on the LRM. The resultant data is made available to the expert system within ICNIA so that real-time fault detection and isolation can be achieved. The objective of the expert system within ICNIA is to detect and isolate faults in near real-time and minimize the false alarm rate. Other aspects of the system are addressed. Author

N92-12540# Wright Lab., Wright-Patterson AFB, OH.
A DEVELOPMENT-MEMORY APPROACH FOR ENHANCING AVIONICS SOFTWARE LOGISTICS
MARC J. PITARYS *In* AGARD, Machine Intelligence for Aerospace Electronic Systems 5 p Sep. 1991
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Advanced avionics systems will execute Ada software on multiple parallel computers. The size and complexity of the avionics software will be massive. Of particular importance is how the software will be supported once it is delivered to the Air Force. Software support is that part of the avionics software life-cycle that deals with the correction of deficiencies and the addition of enhancements to the avionics software. Much of the time spent by personnel is information searching and inferencing. These tasks are made more complicated when information that was useful to the developer is not included in the software documentation that is delivered with the weapon system. The challenges facing avionics software support personnel are covered, and an advanced software support concept called Development-Memory (DM) is addressed. Author

N92-13065*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EFFECT OF SHORT-TERM EXPOSURE TO STEREOSCOPIC THREE-DIMENSIONAL FLIGHT DISPLAYS ON REAL-WORLD DEPTH PERCEPTION
ANTHONY M. BUSQUETS, RUSSELL V. PARRISH, and STEVEN P. WILLIAMS Washington Oct. 1991 26 p
(Contract DA PROJ. 1L1-61102-AH-45)
(NASA-TP-3117; L-16897; NAS 1.60:3117;
AVSCOM-TR-91-B-014) Avail: NTIS HC/MF A03 CSCL 01/4

High-fidelity color pictorial displays that incorporate depth cues in the display elements are currently available. Depth cuing applied to advanced head-down flight display concepts potentially enhances the pilot's situational awareness and improves task performance. Depth cues provided by stereopsis exhibit constraints that must be fully understood so depth cuing enhancements can be adequately realized and exploited. A fundamental issue (the goal of this investigation) is whether the use of head-down stereoscopic displays in flight applications degrade the real-world depth perception of pilots using such displays. Stereoacuity tests are used in this study as the measure of interest. Eight pilots flew repeated simulated landing approaches using both nonstereo and stereo 3-D head-down pathway-in-the-sky displays. At this decision height of each approach (where the pilot changes to an out-the-window view to obtain real-world visual references) the pilots changed to a stereoacuity test that used real objects. Statistical analysis of stereoacuity measures (data for a control condition of no exposure to any electronic flight display compared with data for changes from nonstereo and from stereo displays) reveals no significant differences for any of the conditions. Therefore, changing from short-term exposure to a head-down stereo display has no more effect on real-world relative depth perception than does changing from a nonstereo display. However, depth perception effects based on sized and distance judgements and on long-term exposure remain issues to be investigated. Author

N92-13066# Air Force Systems Command, Wright-Patterson AFB, OH. Foreign Technology Div.
SOVIET ELECTRONIC DISPLAY SYSTEMS UNDER RESEARCH AND MANUFACTURED FOR THE CIVIL AVIATION AIRCRAFT OF THE 1990'S
LING ZHIQIN 25 Jul. 1991 12 p Transl. into ENGLISH from Aviation Production Engineering (China), no. 5, May 1989 p 28 and 29
(AD-A240933; FTD-ID(RS)T-0289-91) Avail: NTIS HC/MF A03 CSCL 14/2

For many years, scientific research and production of on-board electronic equipment on Soviet civil aviation aircraft primarily directed its efforts to the resolution of the problems of guaranteeing a high degree of flight safety, and lowering operating expenses. Lightening the operating responsibilities of the aircrews is an effective method of raising the safety of flying. The operating responsibilities of aircrew personnel are primarily determined by the information capacity and orderliness of the whole set of on-board equipment. The question of lightening aircrew operating responsibilities, in the last ten years, has had special practical significance. The reason for this is that, in this time period, civil aviation aircraft have been equipped with various types of new model guidance and communications gear, automatic flight control equipment, and electric supply equipment. In conjunction with this, there has been a choice to make use of new piloting principles, such as those based on opting for the use of overall energy amount information. GRA

N92-13067# Wright Lab., Wright-Patterson AFB, OH.
LIMITATIONS OF A HOLOGRAPHIC 3-D PIXEL PROJECTOR FOR COCKPIT DISPLAYS
SHAWN L. KELLY and CHARLES T. ROBINSON Aug. 1991 5 p
(AD-A241295; WL-TM-91-601) Avail: NTIS HC/MF A01 CSCL 14/4

One popular approach to increasing the combat capability of an aircraft is to reduce the pilot workload imposed by the interpretation of large quantities of displayed data into useful information. One facet of that workload is the mental exercise required by the pilot to visualize his dynamic three dimensional (3-D) environment given data presented on two dimensional (2-D) cockpit displays. Therefore, it is a primary thrust of cockpit research to explore, develop, and test new display devices which can present data with the full 3-D image characteristics of stereopsis, full look-around, and ocular accommodation so that the magnitude of required mental visualization is greatly reduced. GRA

N92-13858*# Appalachian State Univ., Boone, NC. Dept. of Mathematical Sciences.
BACKGROUND ISSUES FOR ON-LINE AIRCRAFT DOCUMENTATION
C. RAY RUSSELL *In* Old Dominion Univ., NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1991 p 198-201 Sep. 1991
Avail: NTIS HC/MF A12 CSCL 01/4

Currently, almost all aircraft documentation in commercial aircraft cockpits is presented via hardcopy manuals. Several recent projects are aimed at eliminating all paper documentation in cockpits using electronic libraries. Electronic libraries encompass diverse information bases including aircraft system documentation, operations and procedures, checklists, maintenance logs, minimum equipment lists, maps and charts, and flight management information. These electronic libraries are envisioned to be embedded in the avionics so as to provide real time monitoring and display of information. Background issues are examined (motivation, information retrieval models, and preliminary designs) for the on-line presentation of aircraft systems documentation including operations, procedures, and checklists. Author

07

AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

A92-13296
THE PERFORMANCE EVALUATION OF AERODERIVATIVE GAS TURBINES
SHIZHENG ZHANG, JUN JI, and YONGMEI YAO (Chinese Academy of Sciences, Institute of Engineering Thermophysics, Beijing, People's Republic of China) Journal of Engineering

Thermophysics (ISSN 0253-231X), vol. 12, Aug. 1991, p. 242-245. In Chinese. refs

The performance of the gas turbines derived from turboshaft or turbopeller engines can be calculated by the computer programs of the design and off-design point performance of original aeroengines. For the gas turbines derived from turbojet or turbofan engines the nozzle should be removed and the power turbine should be designed. The coupling functions to describe the variation of the gas turbine component characteristics, and the influence of the component characteristic variation on the gas turbine performance and other components, by the solution of the nonlinear equations, including the coupling functions, are presented. Author

A92-14408
OPTIMIZATION OF A LIGHT HELICOPTER WITH ARRIUS POWER PLANTS
JEAN-LUC THOUVENOT (Turbomeca, Bordes, France) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 1127-1146.
Copyright

A development history and current development status evaluation are presented for the Arrius family of light helicopter powerplants, whose variants are in both military and civilian service. Attention is given to the degree of design commonality that has been preserved over the course of design changes associated with output power increases, as well as to the long-term downward trend in specific fuel consumption for these powerplants. While the first design generation of these engines covered the output range from 450 to 1600 shp, the latest variants extend from 450 to 2100 shp. The functions and performance benefits of the digital engine control unit most recently incorporated is discussed. O.C.

A92-14409
DISTORTION TOLERANCE OF THE T800-LHT-800 TURBOSHAFT ENGINE
W. T. COUSINS, R. E. MILLER, and K. K. DALTON (Allied-Signal Aerospace Co., Phoenix, AZ) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 1147-1155. refs
Copyright

Inlet distortion testing performed on the T800-LHT-800 (T800) turboshaft engine is described. Test setup and testing techniques are reviewed and the results of the testing are presented. The effects of pressure distortion, temperature distortion, combined pressure and temperature distortion (in opposing and concurrent patterns), and peak and bulk swirl are shown. The response of a centrifugal compression system is presented and the advantages of a centrifugal compression system over an axial compression system for distortion tolerance are discussed. Author

A92-14709
TEST RESULTS OF THE EXPANDER CYCLE AIR TURBO RAMJET FOR A FUTURE SPACE PLANE
NOBUHIRO TANATSUGU, YOSHIHIRO NARUO (Institute of Space and Astronautical Science, Sagamihara, Japan), ITARU ROKUTANDA, TOMOAKI MIZUTANI, KAZUYUKI HIGASHINO, MASATO OGUMA, and SYOICHI OBATA (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 8 p. refs
(IAF PAPER 91-271) Copyright

ISAS has been engaged in development study on the air-turbo ramjet (ATR) propulsion system to be applied for a future space plane. The ATR engine is a combined-cycle air-breathing propulsion system consisting of a turbojet and a ramjet, using liquid hydrogen as fuel. This engine system was named Atrex because it employs an expander cycle. The feasibility of Atrex is being assessed by sea-level static tests using the 1/4-scale model (Atrex-500) with fan inlet diameter of 300 mm and overall length of 2000 mm. Author

A92-14710
FUEL INJECTION IN HYPERSONIC AIRBREATHING ENGINE
KUO-WEI LIN, YIIN-KUEN FUH, and LAI-CHEN CHIEN (Chung-Cheng Institute of Technology, Tao-Yuan, Republic of China) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 11 p. refs
(IAF PAPER 91-273) Copyright

The performance of hypersonic airbreathing propulsion systems, such as scramjets and ramjets, strongly depends on the good mixing characteristic within a reasonable downstream distance for supersonic combustion. Therefore the fuel injection system with enhanced mixing is greatly important to the design. Various fuel injection systems have been investigated in different speed ranges and flow conditions. In this study, compressible thin-layer Navier-Stokes equations are solved. The algorithm is based on second order upwing, predictor-corrector method. The mixing effect of hypersonic flow in a generic mixed cycle scramjet and the fuel sprayed from the injectors at different speeds is computed. The flow properties are thus investigated. Author

A92-14711
THERMODYNAMIC STRUCTURAL ANALYSIS OF HIGH SPEED PROPULSION SYSTEMS
S. N. B. MURTHY (Purdue University, West Lafayatte, IN) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 17 p. refs
(IAF PAPER 91-278) Copyright

An important aspect of thermodynamic analysis of complex propulsion systems is their structural analysis. The interest is in (1) the role-significance of individual components and (2) the architecture of the system from the point of view of inputs to the system and the desired outputs from it. Considering a system utilizing a certain number of technologies, components and interfaces between components, three sensitivity parameters are defined: structural bond coefficient, external bond coefficient, and architectural effectiveness. The application of those parameters is illustrated for a number of propulsion systems. The outcome of the analysis is of crucial importance in system and component design and architecture. Author

A92-14868
THE ROLE OF LAMINAR-TURBULENT TRANSITION IN GAS TURBINE ENGINES
ROBERT E. MAYLE (Rensselaer Polytechnic Institute, Troy, NY) ASME, Transactions, Journal of Turbomachinery (ISSN 0889-504X), vol. 113, Oct. 1991, p. 509-537. refs
Copyright

A critical study of laminar-turbulent transition phenomena and their role in aerodynamics and heat transfer in modern and future gas turbine engines is presented. In order to develop a coherent view of the subject, a current look at transition phenomena from both a theoretical and experimental standpoint is provided, and a comprehensive state-of-the-art account of transitional phenomena in the engine's throughflow components is given. The impact of transitional flow on engine design is discussed, and suggestions for future research and developmental work are provided. Author

A92-15502
WAVE ENGINE AEROTHERMODYNAMIC DESIGN
HELMUT E. WEBER (Pennsylvania State University, University Park; Flow Energy Engineering, San Diego, CA) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. refs
(ASME PAPER 91-GT-4)

A method for aerothermodynamic preliminary design of a wave engine is presented. The engine has a centrifugal precompressor for the wave rotor which feeds high and low pressure turbines. Three specific wave engine designs are presented. Wave rotor blades are naturally cooled by the ingested air; thus, combustion temperatures can be as high as 1900 K. Engine pressure ratios of over 25 are obtained in compact designs. It is shown that no

nozzles at the end of the rotor blade passages yield the highest cycle efficiencies which can be over 50 percent. Rotor blades are straight and easily milled, cast or fabricated. Author

A92-15519
DEVELOPMENT OF AN INNOVATIVE HIGH-TEMPERATURE GAS TURBINE FUEL NOZZLE
G. D. MYERS, J. P. ARMSTRONG, C. D. WHITE (Allied-Signal Aerospace Co., Garrett Engine Div., Phoenix, AZ), S. CLOUSER (U.S. Navy, Naval Air Propulsion Center, Trenton, NJ), and R. J. HARVEY (Delavan, Inc., Des Moines, IA) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. refs
(Contract N00140-87-C-0836)
(ASME PAPER 91-GT-36)

The objective of the innovative high-temperature fuel nozzle program was to design, fabricate, and test propulsion engine fuel nozzles capable of performance despite extreme fuel and air inlet temperatures. Although a variety of both passive and active methods for reducing fuel wetted-surface temperatures were studied, simple thermal barriers were found to offer the best combination of operability, cycle flexibility, and performance. A separate nozzle material study examined several nonmetallics and coating schemes for evidence of passivating or catalytic tendencies. Two pilotless airblast nozzles were developed by employing finite-element modeling to optimize thermal barriers in the stem and tip. Operability of these prototypes was compared to a current state-of-the-art piloted, prefilming airblast nozzle, both on the spray bench and through testing in a can-type combustor. The three nozzles were then equipped with internal thermocouples and operated at 1600 F air inlet temperature while injecting marine diesel fuel heated to 350 F. Measured and predicted internal temperatures as a function of fuel flow rate were compared. Results show that the thermal barrier systems dramatically reduced wetted-surface temperatures and the potential for coke fouling, even in an extreme environment. Author

A92-15520
ISOTHERMAL FLOW FIELDS IN A RESEARCH COMBUSTOR FOR LEAN BLOWOUT STUDIES
G. J. STURGESS (Pratt and Whitney Group, East Hartford, CT), S. P. HENEGHAN, M. D. VANGSNESS, D. R. BALLAL (Dayton, University, OH), and A. L. LESMERISES (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 12 p. refs
(Contract F33615-87-C-2822; F33615-87-C-2767)
(ASME PAPER 91-GT-37)

A propane-fueled research combustor has been designed and developed to investigate lean blowouts in a simulated primary zone of the combustors for aircraft gas turbine engines. To better understand the flow development and to ensure that the special provisions in the combustor for optical access did not introduce undue influence, measurements of the velocity fields inside the combustor were made using laser Doppler anemometry. These measurements were made in isothermal, constant density flow to relate the combustor flow field development to known jet behavior and to backward-facing step experimental data in the literature. The major features of the flow field appear to be consistent with the expected behavior, and there is no evidence that the provision of optical access adversely affected the flows measured. Author

A92-15524
IMPLANTED COMPONENT FAULTS AND THEIR EFFECTS ON GAS TURBINE ENGINE PERFORMANCE
J. D. MACLEOD (National Research Council of Canada, Ottawa), V. TAYLOR (Standard Aero, Ltd., Winnipeg, Canada), and J. C. G. LAFLAMME (DND, Directorate of Transport, Helicopter Engineering and Maintenance, Ottawa, Canada) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 7 p. refs
(ASME PAPER 91-GT-41)

The objective of the project reported here was to quantify the effects of implanted faults, simulating typical in-service faults, on engine performance. In particular, data are presented for an Allison T56 turboprop engine with a series of installed faulty parts. The faults included 1st stage turbine nozzle erosion damage; 1st stage turbine rotor blade untwist; compressor seal wear; and 1st and 2nd stage compressor blade tip clearance increase. All but one of the four implanted faults were found to be measurable. The worn compressor stator seals did not affect the engine performance enough to be detected. V.L.

A92-15530
MINIMIZATION OF THE NUMBER OF COOLING HOLES IN INTERNALLY COOLED TURBINE BLADES
GEORGE S. DULIKRAVICH and BRANKO KOSOVIC (Pennsylvania State University, University Park) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 6 p. refs
(ASME PAPER 91-GT-52)

This work represents an extension of the earlier research on inverse determination of proper locations and sizes of a given number of coolant flow passages (holes) subject to specified surface temperatures and heat fluxes. The methodology is extended to allow designer to guess the required number of holes and the minimal allowable diameter of a hole. A constrained optimization algorithm is then used to minimize the total number of cooling holes, while satisfying user-specified hot surface temperatures and heat fluxes. Premature termination of the optimization process due to the existence of local minimas has been satisfactorily resolved by automatic switching of the objective function formulation whenever the local minima is detected. The convergence criteria of the iterative process, which can be specified by the user, was found to have a strong influence on the accuracy of the entire inverse design optimization algorithm. Author

A92-15532
TWO-PHASE FLOW CORRELATIONS IN AIR/OIL SYSTEMS OF AERO ENGINES
H. ZIMMERMANN, A. KAMMERER, R. FISCHER, and D. REBHAN (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, Federal Republic of Germany) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 13 p. refs
(ASME PAPER 91-GT-54)

A strategy is outlined on how to introduce two-phase flow correlations into air/oil system calculations for aero engines. The importance of two-phase flow effects is highlighted by demonstrating their particular significance for the high altitude performance of a vent system. For air/oil mixtures very little can be obtained from the literature and correlations derived from air/water test results have to be correlated. For critical flow conditions in restrictors an improved method is developed. Some test data obtained for air/oil mixtures show, that the proposed correlations agree fairly well. Furthermore, it is shown how numerical methods for this complex field of fluid dynamic can be used in the future by the example of phase demixing by centrifugal forces. Author

A92-15538
INVESTIGATION OF ENGINE THRUST CORRELATION METHODS FOR ENCLOSED TEST CELLS
J. W. BIRD, J. D. MACLEOD, and M. F. MULLIGAN (National Research Council of Canada, Institute for Mechanical Engineering, Ottawa) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 6 p. refs
(ASME PAPER 91-GT-68)

A test cell correlation program was carried out to establish a relationship between the performance of a designated F404 gas turbine engine in the National Research Council of Canada (NRCC) test cell No. 5 and the GE test cell 108 at Lynn, Massachusetts. General Electric reported on the test results and provided a test cell correlation method. The test data and methods have been subsequently analyzed. Simplified methods were examined to

provide ready means of correlating other test facilities. Two correlation methods are proposed which compare well with the manufacturer's results. Author

A92-15543
FUTURE TRENDS IN TURBOSHAFT ENGINES UP TO 5000 HORSEPOWER CLASS
ROBERT L. VOGT (Textron Lycoming, Stratford, CT) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 6 p. refs
(Contract DAAJ02-89-C-0035; N00019-89-C-0352; F33657-89-C-2017)
(ASME PAPER 91-GT-74)

The history and evolution of the turboshaft configuration of the gas turbine engine are briefly reviewed, and current and future trends in advanced turboshaft engines in the 4000-6000 shaft horsepower class are discussed. It is predicted that the specific fuel consumption of turboshaft engines will be reduced by one-third; for the same engine power, they will have only fifty percent the size, airflow, and weight. The benefits these advancements will provide to the engine, the vehicle, and the user are discussed. V.L.

A92-15546
THE EFFICIENCIES OF SINGLE-STAGE CENTRIFUGAL COMPRESSORS FOR AIRCRAFT APPLICATIONS
C. RODGERS (Sundstrand Power Systems, San Diego, CA) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 10 p. refs
(ASME PAPER 91-GT-77)

Advances in the last decade have made it appropriate to review the major design parameters influencing the efficiency levels of single-stage centrifugal compressors for aircraft applications. A simple efficiency correlation was derived for advanced single-stage centrifugal compressors based upon four critical parameters: (1) inlet specific speed, (2) impeller tip diameter, (3) inducer tip relative Mach number, and (4) exit discharge Mach number. The correlation was shown to predict attainable state-of-the-art efficiencies within a band width of +/- 2 percentage points. This was considered acceptable for preliminary compressor and engine design work. Author

A92-15552
ACTIVE SUPPRESSION OF ROTATING STALL AND SURGE IN AXIAL COMPRESSORS
I. J. DAY (Cambridge, University, England) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. Research supported by SERC. refs
(ASME PAPER 91-GT-87)

This paper reports on an experimental program in which active control was successfully applied to both rotating stall and surge in a multistage compressor. Two distinctly different methods were used to delay the onset of rotating stall in a four-stage compressor using fast acting air injection valves. The amount of air injected was small compared to the machine mass flow, the maximum being less than 1.0 percent. In some compressor configurations modal perturbations were observed prior to stall. By using the air injection valves to damp out these perturbations an improvement of about 4.0 percent in stall margin was achieved. The second method of stall suppression was to remove emerging stall cells by injecting air in their immediate vicinity. Doing this repeatedly delayed the onset of stall, giving a stall margin improvement of about 6.0 percent. Further studies were conducted using a large plenum downstream of the compressor to induce the system to surge rather than stall. The resulting surge cycles were all found to be initiated by rotating stall and therefore the stall suppression systems mentioned above could also be used to suppress surge. In addition, it was possible to arrest the cyclical pulsing of a compressor already in surge. Author

A92-15553
ACTIVE CONTROL OF ROTATING STALL IN A LOW SPEED AXIAL COMPRESSOR
J. PADUANO, A. H. EPSTEIN, L. VALAVANI, J. P. LONGLEY, E. M. GREITZER, and G. R. GUENETTE (MIT, Cambridge, MA) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 10 p. Research supported by USAF and U.S. Navy. refs
(ASME PAPER 91-GT-88)

The onset of rotating stall has been delayed in a low speed, single-stage, axial research compressor using active feedback control. Control was implemented using a circumferential array of hot wires to sense rotating waves of axial velocity upstream of the compressor. Circumferentially traveling waves were then generated with appropriate phase and amplitude by 'wiggling' inlet guide vanes driven by individual actuators. The control scheme considered the wave pattern in terms of the individual spatial Fourier components. A simple proportional control law was implemented for each harmonic. Control of the first spatial harmonic yielded an 11-percent decrease in the stalling mass flow, while control of the first and second harmonics together reduced the stalling mass flow by 20 percent. The control system was also used to measure the sine wave response of the compressor, which behaved as would be expected for a second-order system. Author

A92-15560
LIFE TIME PREDICTION FOR CERAMIC GAS TURBINE COMPONENTS
G. STUERMER, A. SCHULZ, and S. WITTIG (Karlsruhe, Universitaet, Federal Republic of Germany) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 7 p. refs
(ASME PAPER 91-GT-96)

At the Institute for Thermal Turbomachinery, University of Karlsruhe (ITS), theoretical and experimental investigations on ceramic gas turbine components are performed. For the reliability analysis by finite element calculations the computer code CERITS has been developed. This code is used to determine the fast fracture reliability of ceramic components subjected to polyaxial stress states with reference to volumetric flaws and was presented at the 1990 IGTI Gas Turbine Conference. CERITS-L now includes subcritical crack growth. With the new code CERITS-L, failure probabilities of ceramic components can be calculated under given load situations versus time. In comparing these time dependent failure probabilities with a given permissible failure probability, the maximum operation time of a component can be determined. The considerable influence of the subcritical crack growth upon the life time of ceramic components is demonstrated at the flame tube segments of the ITS ceramic combustor. Author

A92-15561
THE INFLUENCE OF BLADE LEANING ON THE PERFORMANCE OF AN INTEGRATED OGV-DIFFUSER SYSTEM
J. F. CARROTTE, S. J. STEVENS, and A. P. WRAY (Loughborough University of Technology, England) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 9 p. Research supported by Ministry of Defence of England. refs
(ASME PAPER 91-GT-104)

An experimental investigation has been carried out to study the performance of an integrated design of compressor outlet guide vane (OGV) and combustor prediffuser system. The trailing edge of each OGV was located within the outwardly canted diffuser by a distance equal to 27 percent of the diffuser axial length. In order to obtain representative inlet conditions, a rotor, providing a fully sheared velocity profile, and an air outlet angle of approximately 40 deg, was located upstream of the OGVs. Compared with the measured performance when the trailing edge of each OGV was located at diffuser inlet, a small increase in total pressure loss and a corresponding decrease in static pressure recovery was observed for the shortened system. This change in performance reflected a deterioration in the flow conditions along

the outer wall, with transitory stalling of the flow being observed at diffuser exit. By leaning the blades in a circumferential direction through angles of 10 deg and 15 deg, the outlet wall flow conditions could be progressively improved, although at the largest angle tested, stalling of the flow occurred at the hub of each OGV. However, at a lean angle of 10 deg, the performance, in terms of loss and flow stability, could be virtually restored to the levels obtained when the trailing edge of each OGV was located radially at diffuser inlet. Author

A92-15566* Allied-Signal Aerospace Co., Phoenix, AZ.
IMPACT DESIGN METHODS FOR CERAMIC COMPONENTS IN GAS TURBINE ENGINES
J. SONG, J. CUCCIO, and H. KINGTON (Allied-Signal Aerospace Co., Garrett Auxiliary Power Div., Phoenix, AZ) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 9 p. Research supported by DOE. refs
(Contract DEN3-335)
(ASME PAPER 91-GT-115)

Methods currently under development to design ceramic turbine components with improved impact resistance are presented. Two different modes of impact damage are identified and characterized, i.e., structural damage and local damage. The entire computation is incorporated into the EPIC computer code. Model capability is demonstrated by simulating instrumented plate impact and particle impact tests. R.E.P.

A92-15591* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
RELIABILITY ANALYSIS OF A STRUCTURAL CERAMIC COMBUSTION CHAMBER
JONATHAN A. SALEM, JANE M. MANDERSCHEID, MARC R. FREEDMAN, and JOHN P. GYEKENYESI (NASA, Lewis Research Center, Cleveland, OH) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. Previously announced in STAR as N90-28112. refs
(ASME PAPER 91-GT-155)

The Weibull modulus, fracture toughness and thermal properties of a silicon nitride material used to make a gas turbine combustor were experimentally measured. The location and nature of failure origins resulting from bend tests were determined with fractographic analysis. The measured Weibull parameters were used along with thermal and stress analysis to determine failure probabilities of the combustor with the CARES design code. The effect of data censoring, FEM mesh refinement, and fracture criterion were considered in the analysis. Author

A92-15598
THE IMPACT LOAD ON CONTAINMENT RINGS DURING A MULTIPLE BLADE SHED IN AIRCRAFT GAS TURBINE ENGINES
T. B. DEWHURST (Maine, University, Orono) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 7 p. Research supported by University of Maine. refs
(ASME PAPER 91-GT-163)

In the event of a multiple blade shed in an aircraft gas turbine engine, the impact load upon the containment ring is critical. A complete understanding of this load is necessary to design optimal rings, which are strong enough to contain blade fragments without incurring excess weight penalties. In this study a description of a multiple blade shed and subsequent ring failure is given. A finite element analysis of actual engine experiments is then used to determine the impact load on containment rings during a multiple blade shed. The situation modeled here is one where the initial blade fragments are contained but subsequent blade failures create large hoop stresses that result in brittle tensile failures in the ring. Author

A92-15599
TURBINE BLADE TIP CLEARANCE IMPROVEMENT
B. GLEZER (Solar Turbines, Inc., San Diego, CA) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. refs
(ASME PAPER 91-GT-164)

A recently developed nontraditional design concept addressing turbine blade tip clearance reduction to provide long-term engine performance improvement and stability is presented. The concept is based on the direct attachment of the diaphragm, which supports Stage 1 integral nozzle and tips shroud segments, to the bearing housing, thus providing a close thermal link between the rotor and the stator. Transient thermal matching between the rotating and stationary structures was based on analytical prediction. Results of the complex turbine hot section study including cooling flow, thermal, stress, and deflection analyses are presented. An advanced tip clearance measurement technique was used in the full scale engine test to verify the analytical predictions. The potential to reduce tip clearance to less than 1 percent of blade height without blade tip rubs has been demonstrated. Extensive field operating experience with more than 100 Centaur Type 'H' engines showed very light or no blade tip rub and corresponding engine performance stability during long-term operation. Author

A92-15600
GAS TURBINE MAIN SHAFT INTERNAL FLOW AND HEAT TRANSFER
DAVID V. ROSCOE, RICHARD C. BUGGELN (Scientific Research Associates, Inc., Glastonbury, CT), PETER M. MUNSELL, and F. C. HSING (Pratt and Whitney Group, East Hartford, CT) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 7 p. refs
(ASME PAPER 91-GT-165)

A CFD analysis of the cooling flow through a gas turbine engine low pressure turbine shaft is presented. Three cases are considered in which throughflow and rotation rate are varied. The primary objective of the analysis was to derive improved heat transfer coefficient information, over those obtainable via semi-empirical means. The coefficients so obtained were then used in a one-dimensional, time-dependent analysis for use in predicting shaft wall temperature throughout a snap acceleration phase of the engine. A second objective was to obtain insight into the flow structure within the shaft with a view to possible design input in future engine programs. Results presented include detailed velocity vector plots at select locations, heat transfer coefficient distributions for each case and finally, for Case 2 predicted wall temperature vs. time is shown in conjunction with engine test data. Author

A92-15605
ANALYTICAL INVESTIGATION OF THE RULES OF COMPONENT MATCHING IN TURBOJET ENGINES
DAO-ZHI LIU (Beijing University of Aeronautics and Astronautics, People's Republic of China) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 5 p. refs
(ASME PAPER 91-GT-170)

In turbojet engines, phenomena under off-design conditions are related to the variations of incidence angles at different compressor stages. In the present paper, analytical formula about the off-design incidence variations of inlet and exit compressor stages are derived. Using these formulae, the detailed rules about engine parameter variations under off-design conditions are obtained; a series of phenomena about engine performance for low and high pressure ratio engines, engines with axial, centrifugal and combined compressors, as well as single-shaft and two-spool engines can then be explained systematically, their physical essence will be revealed clearly; and a variety of new situations and problems about engine off-design behavior can be predicted in advance. Author

A92-15612
THE TORSIONAL STABILITY OF A COMPRESSOR CASCADE
M. R. D. DAVIES (Limerick, University, Republic of Ireland) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 7 p. Research supported by

Rolls-Royce, PLC. refs
(ASME PAPER 91-GT-180)

This paper includes new experimental data on the torsional stability of a compressor or fan type of blade row. This data is linked in with published material to form a three dimensional figure describing the stability of such rows. The data is then discussed by considering relative values of influence coefficients and some of the trends in the stability figure are explained. New data is also included on the relative magnitudes and phases of the influence coefficients. Author

A92-15618
ONE-DIMENSIONAL, STAGE-BY-STAGE, AXIAL COMPRESSOR PERFORMANCE MODEL
MARK S. JOHNSON (California Polytechnic State University, San Luis Obispo) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. Research sponsored by EPRI. refs
(ASME PAPER 91-GT-192)

This paper presents a description of a 1D, constant-radius, stage-by-stage (blade-element) axial compressor model used for compressor map generation and gas turbine off-design performance prediction. This model is designed for investigators who are without access to the proprietary compressor performance information of the gas turbine manufacturers but who are nevertheless interested in predicting the off-design performance of large utility gas turbine power systems. Model performance results (compressor maps) are reported for simulation of a nineteen-stage axial compressor. The model is further demonstrated by simulating the NACA Eight Stage compressor. The resulting compressor maps are in good qualitative agreement with published maps and are useful for gas turbine power system performance simulation studies. This general-purpose modeling procedure can be applied to any axial compressor for which sufficient airfoil geometry and design-point performance information is known. Author

A92-15619
INTERACTIVE ENGINE SYSTEM DYNAMICS ANALYSIS
A. F. STORACE (GE Aircraft Engines, Cincinnati, OH) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 13 p. refs
(ASME PAPER 91-GT-193)

A vibration interactive system analysis (VISA) computer program has been developed to facilitate system vibration and maneuver loads analysis and to improve its quality. The VISA interactive analysis utilizes a combined transfer matrix/finite-element formulation. In the former case, the dimensionality of the analysis is reduced, and in the latter case, automatic analysis of multibranch, multilevel engine structures, and a generalized approach to modeling various types of boundary and constraint conditions is provided. O.G.

A92-15620
DESIGN OF A SMALL AXIAL COMPRESSOR FOR HIGH EFFICIENCY OVER A WIDE OPERATING RANGE
B. REYNOLDS, S. ETTER, J. TORONY, and J. O'CONNOR (Textron Lycoming, Stratford, CT) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 9 p. refs
(ASME PAPER 91-GT-195)

Innovative aerodynamic and mechanical design features identified in previous technology-development programs have been used to optimize the efficiency and operating range of a three-stage small flow-class axial compressor. The design employs: (1) rotor airfoils that are customized for minimum shock loss; (2) airfoil endwall loadings selected to reduce losses; (3) variable-geometry design for wide range and high efficiency; (4) flowpath sealing for low leakage flow; and (5) variable stator hub contours and attachment design for minimum clearance loss. Performance objectives have been verified via prototype rig testing. Meanline, axisymmetric, and 3D flow analyses have been conducted to characterize compressor aerodynamics. O.C.

A92-15626
A DIRECT OPTIMIZATION PROCEDURE FOR SPANWISE WORK DISTRIBUTION IN NON-FREE VORTEX TURBINE STAGES
RHONALD M. JENKINS (Auburn University, AL) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. refs
(ASME PAPER 91-GT-204)

This paper describes a technique for finding the radial distributions of flow angle and stage specific work which yield, subject to user-specified constraints, the maximum value of integrated adiabatic efficiency for a turbine stage. The optimization procedure is direct in that the distributions are specified as polynomials. A pattern search is employed to determine the values of the polynomial coefficients which yield the desired conditions. The overall technique is intended to supplement the preliminary phase of axial flow gas turbine design. Author

A92-15633
REAL-TIME ESTIMATION OF GAS TURBINE ENGINE DAMAGE USING A CONTROL BASED KALMAN FILTER ALGORITHM
L. J. KERR, T. S. NEMEC, and G. W. GALLOPS (Pratt and Whitney Group, West Palm Beach, FL) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 9 p. refs
(ASME PAPER 91-GT-216)

A second generation Kalman filter algorithm is described that has sufficient accuracy and response for real-time detection and estimation of gas turbine engine gas path damage caused by normal wear, mechanical failures and ingestion of foreign objects. The algorithm was developed for in-flight operation of aircraft engines but also has application for marine and industrial gas turbines. The control measurement and microcomputer requirements are described. The performance and sensitivity to engine transients and measurement errors is evaluated. The algorithm is demonstrated with actual engine data of ice and bird ingestion tests. Author

A92-15634* CFD Research Corp., Huntsville, AL.
CFD ANALYSIS OF JET MIXING IN LOW NO(X) FLAMETUBE COMBUSTORS
M. V. TALPALLIKAR, C. E. SMITH (CFD Research Corp., Huntsville, AL), M. C. LAI (Wayne State University, Detroit, MI), and J. D. HOLDEMAN (NASA, Lewis Research Center, Cleveland, OH) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 10 p. Previously announced in STAR as N91-26146. refs
(Contract NAS3-25834)
(ASME PAPER 91-GT-217)

The Rich-burn/Quick-mix/Lean-burn (RQL) combustor has been identified as a potential gas turbine combustor concept to reduce NO(x) emissions in High Speed Civil Transport (HSCT) aircraft. To demonstrate reduced NO(x) levels, cylindrical flametube versions of RQL combustors are being tested at NASA Lewis Research Center. A critical technology needed for the RQL combustor is a method of quickly mixing by-pass combustion air with rich-burn gases. Jet mixing in a cylindrical quick-mix section was numerically analyzed. The quick-mix configuration was five inches in diameter and employed twelve radial-inflow slots. The numerical analyses were performed with an advanced, validated 3D Computational Fluid Dynamics (CFD) code named REFLEQS. Parametric variation of jet-to-mainstream momentum flux ratio (J) and slot aspect ratio was investigated. Both non-reacting and reacting analyses were performed. Results showed mixing and NO(x) emissions to be highly sensitive to J and slot aspect ratio. Lowest NO(x) emissions occurred when the dilution jet penetrated to approximately mid-radius. The viability of using 3D CFD analyses for optimizing jet mixing was demonstrated. Author

A92-15636
THE DESIGN AND TESTING OF A RADIAL FLOW TURBINE FOR AERODYNAMIC RESEARCH
I. HUNTSMAN, H. P. HODSON (Cambridge, University, England),

and S. H. HILL (Rolls-Royce, PLC, Leavesden, England) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 7 p. Research supported by Rolls-Royce, PLC and Rolls-Royce Business Ventures, Ltd. refs
(ASME PAPER 91-GT-220)

This paper describes the design of a high-speed radial inflow turbine for use as part of a gas-generator, and the design of a large-scale (1.2 m tip dia.) low-speed model of the high-speed turbine. Streamline curvature throughflow, two-dimensional blade-to-blade and fully three-dimensional inviscid and viscous calculation methods have been used extensively in the analysis of the designs. The use of appropriate scaling parameters and their impact on turbine performance is discussed. A simple model shows, for example, how to model the blade lean in the inducer which serves to balance the effect of meridional curvature at inlet to the rotor and can be used to unload the rotor tip. A brief description of the low-speed experimental facility is followed by a presentation and discussion of experimental results. These include surface flow visualization patterns on both the rotor and stator blades and blade row exit traverses. Author

A92-15643
WEAK EXTINCTION LIMITS OF LARGE SCALE FLAMEHOLDERS
A. H. LEFEBVRE (Purdue University, West Lafayette, IN) and M. R. BAXTER ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 7 p. refs
(ASME PAPER 91-GT-234)

Weak extinction data obtained from an experimental apparatus designed to simulate the characteristics of practical afterburner combustion systems are presented. The apparatus supplies mixtures of varied composition (equivalence ratio and degree of vitiation), temperature and velocity to Vee-gutter flame holders of various widths and shapes similar to those found in jet engine systems. The fuel employed is a liquid hydrocarbon whose chemical composition and physical properties correspond to those of aviation kerosene, JP5. An equation for predicting weak extinction limits which accounts for upstream vitiation and the chemical characteristics of the fuel is derived from stirred reactor theory. The correlation between the predictions and experimental results indicates that the stirred reactor approach can provide a framework for predicting the lean blowout limits of practical flameholders over wide ranges of engine operating conditions. Author

A92-15645* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
STUDY OF EXTERNAL DYNAMIC FLAP LOADS ON A 6 PERCENT B-1B MODEL
JOHN M. SEINER, JAMES C. MANNING, FRANCIS J. CAPONE, and ODIS C. PENDERGRAFT, JR. (NASA, Langley Research Center, Hampton, VA) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 17 p. refs
(ASME PAPER 91-GT-236)

The origin of dynamic pressure loads on external divergent engine nozzle flaps of the B-1B aircraft was investigated in the NASA/LaRC 16 foot transonic tunnel using a 6 percent full span model with powered engine nacelles. External flap dynamic loads and afterbody drag associated with flap removal were measured using this model. Both dry and max. A/B power nozzles were evaluated in this study. As a result of this study, the principal mechanisms responsible for high dynamic external flap loads were determined along with performance penalty associated with flap removal. Author

A92-15674
CONTROL SYSTEMS FOR THE NEXT CENTURY'S FIGHTER ENGINES
CHARLES A. SKIRA (USAF, Aero Propulsion and Power Laboratory, Wright-Patterson AFB, OH) and MARK AGNELLO (U.S. Navy, Naval Air Propulsion Center, Trenton, NJ) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 7 p. refs
(ASME PAPER 91-GT-278)

The paper describes a conceptual control system design based on advanced technologies currently in the exploratory development phase, and, in some cases, emerging into the advanced development phase. It explores future propulsion control systems that focus on improvements in three (3) areas: (1) significantly reducing control system weight; (2) enhancing engine performance (thrust, sfc, etc.); and (3) improving control system reliability and tolerance to high threat environments (temperature, vibration, EMI, EMP, etc.). The factors that will influence the design and hardware configuration of future propulsion control systems are described. Design goals for future systems, based on the DOD/NASA IHPTET initiative, and projections of emerging technology capability (and availability) form the basis for future propulsion control system design requirements and for estimating future hardware configurations. Author

A92-15678
BLADE ROW INTERACTION IN A MULTISTAGE LOW-PRESSURE TURBINE
N. ARNDT (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, Federal Republic of Germany) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 11 p. refs
(ASME PAPER 91-GT-283)

The objective of this work was to enhance the understanding of unsteady flow phenomena in multistage low-pressure turbines. For this purpose, hot-film probe measurements were made downstream of every rotor blade row of a five-stage low-pressure turbine. Rotor-rotor interaction and stator-rotor interaction were observed to have a profound influence on the flow through the low-pressure turbine. Interaction of rotors of different turbine stages occurred owing to the influence of the wakes shed by one rotor blade row upon the flow through the next downstream rotor blade row. This wake-induced rotor-rotor interaction resulted in strongly amplitude-modulated periodic and turbulent velocity fluctuations downstream of every rotor blade row with the exception of the most upstream one. Significantly different wake depths and turbulence levels measured downstream of every rotor blade row at different circumferential positions evidenced the effect of the circumferentially nonuniform stator exit flow upon the next downstream rotor blade row. Stator-rotor interaction also strongly influenced the overturning and the undertuning of the rotor wakes, caused by the rotor secondary flows, in the rotor endwall regions. Low rotor wake overturning and underturning, i.e., reduced rotor secondary flow influence, were observed to correlate well with low rotor wake turbulence levels. Author

A92-15679
INTEGRATED FLIGHT/PROPULSION CONTROL FOR FLIGHT CRITICAL APPLICATIONS - A PROPULSION SYSTEM PERSPECTIVE
KENNETH D. TILLMAN and TIMOTHY J. IKELER (Pratt and Whitney Group, West Palm Beach, FL) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 12 p. refs
(ASME PAPER 91-GT-284)

The results of the Interface II Integral Flight and Propulsion Control program, whose goal is to validate and demonstrate high-risk, high-payback technologies for future development program applications, are presented. It is shown that functional control integration of thrust vectoring/reversing nozzles and aerodynamic controls surfaces can be effectively accomplished with suitable dynamics to provide supermaneuverable aircraft operation. The use of pitch vectoring, yaw vectoring, and reversing nozzles as primary control effectors at low air speeds in combination with robust control laws and a control selector yields greatly enhanced aircraft agility through the entire flight envelope. Design considerations for the development of a flight-critical integrated propulsion system are addressed. C.D.

A92-15687
SIMPLE FORMULAE FOR OPTIMAL SOLIDITY OF TWO-DIMENSIONAL COMPRESSOR CASCADES BASED ON DIFFUSION CONCEPT
GAO-LIAN LIU (Shanghai Institute of Mechanical Engineering, People's Republic of China) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 6 p. refs
(ASME PAPER 91-GT-308)

The optimal solidity problem of two-dimensional compressor cascades is formulated as two nonlinear programming problems, in which either the profile losses are minimized or the blade loading is maximized subject to an inequality constraint on the equivalent diffusion ratio or diffusion factor (Lieblein, 1959, 1965). Analytical solutions to these two mathematical programming problems are obtained in the form of simple formulas, which are very convenient for practical use. A rational way for extending their application to 3D compressor bladings is also suggested. Author

A92-15691
DEVELOPMENT AND BENCH TEST OF HIGH-TEMPERATURE COMBUSTION CHAMBER WITH STRUCTURAL CERAMIC COMPONENTS
A. V. SUDAREV, IU. I. ZAKHAROV, G. N. LIUBCHIK, L. S. BUTOVSKII, and E. A. GRANOVSKAIA (Vsesoiuznyi Nauchno-Issledovatel'skii Tekhnologicheskii Institut Energeticheskogo Mashinostroeniia, Leningrad, USSR; Kievskii Politekhnicheskii Institut, Kiev, Ukrainian SSR) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 3 p. refs
(ASME PAPER 91-GT-315)

The paper describes the design of an efficient high-temperature combustion chamber with a ceramic dome for a combustor that is intended to operate with the air preheated at the inlet to 900 C. Results of tests showed that the combustor is capable of high serviceability over a wide range of operational parameters. At a combustor inlet air temperature of 600 C, the maximum temperature of the flameholder wall was 800 C and the maximum temperature of the liner was 1000 C. I.S.

A92-15699
PRELIMINARY DESIGN OF AXIAL COMPRESSORS USING ARTIFICIAL INTELLIGENCE AND NUMERICAL OPTIMIZATION TECHNIQUES
GEORGE HOLT and STUART BASSLER (GE Aircraft Engines, Lynn, MA) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 7 p. Research supported by GE Aircraft Engines. refs
(ASME PAPER 91-GT-334)

This paper discusses an automated method for optimizing multistage axial compressor designs using a generic design software shell called Engineous, coupled with an aerodynamic compressor design program called Compressor Unification Study 5 (CUS5). Engineous combines heuristic searching and numerical optimization techniques, and expert systems to explore the design space of turbomachinery components by iterating preliminary design analysis programs written in languages such as FORTRAN and C. The application design and development process and the lessons learned are discussed for the Engineous/CUS5 axial compressor application. This particular application calculates and maintains compressor stall prediction values while optimizing at the operating (design) point, and requires a design vs. stall comparison during each iteration. A trial compressor design problem was investigated using the Engineous application, and the preliminary results of the study are included. Also introduced is a method for varying flowpath walls using shape criteria rather than radii points. Author

A92-15700
DESIGN AND ANALYSIS OF A HIGH PITCH TO CHORD RATIO CASCADE REPRESENTATIVE OF DUCTED PROPFANS
A. WEBER, W. STEINERT, and H. STARKEN (DLR, Institut fuer Antriebstechnik, Cologne, Federal Republic of Germany) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 11 p. refs
(ASME PAPER 91-GT-335)

One concept for higher-bypass commercial aircraft propulsion is a counterrotating shrouded propfan operating at low overall pressure ratio and only a few fan blades of extremely high pitch/chord ratio. A propfan cascade has been designed with two of the characteristics of such a propfan blade-blade section: (1) a very high pitch/chord ratio, and (2) an inlet Mach number of 0.9, which leads to transonic flow conditions within the blade passage. The cascade design was experimentally verified in transonic cascade wind tunnel tests; the design goal of about 5-deg flow turning is confirmed by test results. O.C.

A92-15719
A PROPULSION PERSPECTIVE OF THE NEXT GENERATION SUPERSONIC TRANSPORT
P. D. FEIG and S. C. GILKEY (GE Aircraft Engines, Cincinnati, OH) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 7 p. refs
(ASME PAPER 91-GT-385)

In order to become a reality, the second generation supersonic transport must be both environmentally acceptable and economically competitive with future subsonic aircraft. Current research is now focused on addressing the major environmental issues of airport noise, engine emissions, and sonic boom. A variety of engine and exhaust nozzle concepts is being studied to validate the emissions and acoustics technologies needed for this aircraft. This paper provides an insight into ongoing research and highlights the propulsion system's influence on the viability of the second-generation SST. Author

A92-15720
THE SELECTIVE BLEED VARIABLE CYCLE ENGINE
MARCO A. R. DO NASCIMENTO and PERICLES PILIDIS (Cranfield Institute of Technology, England) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 7 p. refs
(ASME PAPER 91-GT-388)

A new concept in aircraft propulsion is described in this paper. A variable cycle jet engine is being investigated for a supersonic STOVL aircraft. The engine is the selective bleed turbofan, a two shaft three compressor engine. At low flight speeds this engine operates as a medium bypass turbofan, and for the supersonic cruise condition it operates as a low bypass ratio turbofan in the dry mode. In this paper, the performance of the engine and some of the components is analyzed. Off-design engine performance characteristics are explained, compressor running lines are shown, and variable geometry requirements are described. The performance analysis shows that fuel savings are significant, thus reducing aircraft take-off weight. The major advantage of this engine is that all the components are employed all the time, for all operating modes, thus incurring low weight penalities. Author

A92-15721
OFF-DESIGN PERFORMANCE PREDICTION OF TURBOFANS USING GASDYNAMICS
F. S. MIRZA-BAIG and H. I. H. SARAVANAMUTTOO (Carleton University, Ottawa, Canada) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. Research supported by NSERC. refs
(ASME PAPER 91-GT-389)

This paper describes a mathematical model by which the off-design performance of turbofans can be predicted, knowing just the design point parameters. Off-design performance has been estimated by using gasdynamic properties of the exhaust nozzles, which regulate the aerothermodynamic behavior of the upstream components. Approximate overall performance of a turbofan at typical cruising conditions can be estimated, making the use of compressor and turbine maps redundant. Author

A92-15723
PROPULSION REQUIREMENTS FOR HIGH ALTITUDE LONG ENDURANCE FLIGHT
ROGER W. GALLINGTON (Science Applications International Corp., Vehicle Integration Div., Seattle, WA) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 5 p. refs
(ASME PAPER 91-GT-393)

This paper presents a set of general propulsion system performance requirements for high altitude long endurance flight. Some differences in overall vehicle design that suggest unusual propulsion systems are: (1) optimum wing loadings for endurance at altitude are lower than acceptable for adequate wind penetration during descent and control during landing; (2) compressing and cooling air at high altitudes requires large apparatus, making specific air consumption very important; and (3) the lower specific power requirement and large fuel fractions make fuel consumption relatively more important than system weight. Based on the realistic expectations of aircraft aerodynamic performance and structural efficiency, the paper derives the correct propulsion system trade-offs and extends these trade-offs to include electrically-powered aircraft. Author

A92-15725
PROPULSION ASPECTS OF HYPERSONIC TURBO-RAMJET-ENGINES WITH SPECIAL EMPHASIS ON NOZZLE/AFTBODY INTEGRATION
H. HERRMANN (Deutsche Aerospace AG; MBB GmbH, Munich, Federal Republic of Germany) and H. RICK (Muenchen, Technische Universitaet, Munich, Federal Republic of Germany) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 9 p. refs
(ASME PAPER 91-GT-395)

For hypersonic transport vehicles with combined turbo-ramjet engines operating in the Mach 0 to 6(+) regime, the exhaust nozzle/aftbody configuration is one of the most important areas of design. The variable and controllable hot gas single expansion ramp nozzles, coupled with different bypass and boundary layer flows, represent highly integrated propulsion/airframe-systems. These exhaust systems influence considerably the vectorial force and moment balance of the total aircraft. This paper presents examples of some concept studies of generic nozzle configurations calculated by different CFD methods for selected flight regimes. Author

A92-15727
A LOW NOISE PROPULSION CONCEPT FOR THE SUPERSONIC TRANSPORT
G. A. CHAMPAGNE, G. E. ALLEN, M. PALMIERI, and R. M. ADLER ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 6 p. refs
(ASME PAPER 91-GT-397)

The major challenges with the design of propulsion systems for High speed Civil Transports (HSCT) are complying with FAR and EPA environmental standards while powering an economically acceptable aircraft. Previous studies have shown that to meet FAR Stage 3 noise regulations, engines incorporating mechanical/thermal noise suppression concepts must be oversized by 50 to 80 percent relative to the size that will provide the maximum aircraft economics. In order to achieve the Stage 3 noise levels without oversizing the engine, the engine airflow must be increased by 120 percent during takeoff operation to reduce the average exhaust velocity to an acceptable level. This paper will examine a concept that brings in 74 percent additional airflow into the engine's inlet and 46 percent into the engine's exhaust nozzle. The impacts of this concept on engine design, performance, size and weight and on aircraft takeoff gross weight (TOGW) and range are evaluated. For the same TOGW aircraft, this noise reduction concept provides a 70 percent range improvement relative to engines which incorporate mechanical/thermal noise suppressors. This concept was developed under a NASA sponsored program. Author

A92-15728
DEVELOPMENT OF A LUBRICATION SYSTEM FOR THE T800-LHT-800 TURBOSHAFT ENGINE
LAURA M. DOUGLAS (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p.
(ASME PAPER 91-GT-398)

The T800-LHT-800 military helicopter-powering turboshaft engine's lubrication system must furnish continuous lubrication for an engine operational attitude envelope range of 120-deg noseup, 90-deg nosedown, and 48 deg rolls in either direction. A contractually entailed preclusion of oil loss for up to six min led to the incorporation of an emergency oil system whose design was arrived at via multiple iterations and bench testing on a simulator rig. Attention is presently given to the evolution of the main oil tank attitude capabilities and the qualification/certification test plan. O.C.

A92-15729
LIQUID COOLED TURBOCHARGED PROPULSION SYSTEM FOR HALE APPLICATION
R. E. WILKINSON and R. B. BENWAY (Teledyne Continental Motors, Mobile, AL) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. refs
(ASME PAPER 91-GT-399)

Mission lengths for High Altitude Long Endurance (HALE) applications are typically measured in days rather than hours with operating altitudes ranging from 50,000 to 100,000 feet. An Otto cycle propulsion system offers significant performance advantages over other cycles. A technical assessment is provided of a liquid-cooled, turbocharged, reciprocating engine concept capable of meeting the requirements for a HALE vehicle. A properly designed spark ignition engine with a two- or three-stage series turbocharger system can meet the challenges presented at these altitudes. Several records for long endurance and high altitude flight have already been set with this type of propulsion system. The ability to operate with low brake specific fuel consumption (BSFC) across a broad operating range is identified. With sufficiently high exhaust gas temperatures, the addition of a power turbine for turbocompounding can further reduce the BSFC and brake specific air consumption (BSAC). A version of the turbocharged spark ignition engine is capable of providing high thermal efficiency with the least BSAC and minimum turbomachinery weight. Author

A92-15732
A GLOBAL APPROACH IN EVALUATING INLET/ENGINE COMPATIBILITY
FRANK L. CSAVINA and RUSSELL K. DENNEY (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 13 p. refs
(ASME PAPER 91-GT-402)

Modern weapon systems demands are forcing engine designers to draw a finer line in their trades between performance and compatibility. Next generation smart engine controls also have the flexibility to optimize (real-time) either performance or compatibility knowing the flight condition and aircraft attitude. This paper presents a global statistical approach for the evaluation of installed aircraft/engine compatibility. The proposed methodology uses a Monte Carlo simulation to analyze the complex interaction of randomly occurring destabilizing events. Planned or projected aircraft operational usage and bleed and power offtake demand data are combined with data from an inlet distortion model and an engine model to predict remaining surge margin for the given operational usage. The result is a predicted probability of surge per thousand engine flight hours. Thus, the procedure yields a quantitative total system or global assessment of the probability of engine surge, thereby providing designers expanded insight into inlet/engine compatibility decisions. Author

A92-15738
PROPULSION SYSTEM EVALUATION FOR AN UNMANNED HIGH ALTITUDE LONG ENDURANCE RPV
EDWARD J. KOWALSKI, NORMAN C. BAULLINGER, and JENNIFER KOLDEN (Boeing Co., Military Airplanes Div., Seattle, WA) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 11 p.
(ASME PAPER 91-GT-409)

Unmanned High-Altitude Long-Endurance (HALE) aircraft have been studied for several years. Reconnaissance, surveillance, search and rescue, drug interdiction, atmospheric sampling, etc, are a few of the potential missions for HALE aircraft. One of the pacing technology items for an aircraft of this type is the propulsion system. This paper discusses three candidate propulsion systems: a turbocompounded spark ignition engine, a recuperative turboshaft engine and a turbocharged turbocompounded diesel-turbine. HALE mission requirements dictate that certain parameters influence the selection of the propulsion system: propulsion system weight/horsepower, brake specific fuel consumption (1b/hr/shp), and reliability. Author

A92-16584
THE ROLE OF PRIMARY JET INJECTION ON MIXING IN GAS TURBINE COMBUSTION
C. D. RICHARDS and G. S. SAMUELSEN (California, University, Irvine) IN: Symposium (International) on Combustion, 23rd, Orleans, France, July 22-27, 1990, Proceedings. Pittsburgh, PA, Combustion Institute, 1991, p. 1071-1077. refs
(Contract F08635-86-C-0309)
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The role of primary jet injection on the aerothermal structure and overall performance of a model gas turbine combustor is addressed in an experimental study. The impact of momentum ratio between the primary jets and the swirl air as well as the relative position of the jet row to the swirler injection plane are investigated in a combustor operated on propane at atmospheric pressure. The aerodynamic and thermal fields are characterized using laser anemometry and a thermocouple probe respectively. Species concentrations are acquired at the exit plane via extractive probe sampling. Four regimes are identified that describe the degree of interaction of the primary jets with the swirl-induced recirculation zone. For each regime, the degree of jet penetration and entrainment in the recirculation zone and, as a result, the aerothermal structure of the dome region are substantially different. Author

A92-16585
ACTIVE CONTROL FOR GAS TURBINE COMBUSTORS
J. BROUWER, B. A. AULT, J. E. BOBROW, and G. S. SAMUELSEN (California, University, Irvine) IN: Symposium (International) on Combustion, 23rd, Orleans, France, July 22-27, 1990, Proceedings. Pittsburgh, PA, Combustion Institute, 1991, p. 1087-1092. Research supported by Parker Hannifin Corp. refs
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Closed-loop feedback control is implemented in two model combustors as a demonstration of the application of feedback control to gas turbine combustion. The first combustor is an axisymmetric, swirl-stabilized, spray-fired combustor, while the second combustor incorporates discrete wall injection of primary and dilution air, representative of an actual gas turbine combustor. In both combustors, the emission of CO and CO2, the radiative heat flux to the liner associated with soot, and combustor stability are monitored in real time and controlled as a function of combustor load. The control input to the system is the nozzle atomizing air flow rate. The emission of CO and CO2, the radiative flux to the liner, and the combustor stability are obtained through nonintrusive radiometric sensors mounted near the combustor exit plane. This information is conveyed to a control computer which invokes an optimization algorithm to minimize the CO and soot radiative flux, while maximizing the CO2 radiative flux. The index of combustion instability (onset of elevated acoustic emission) is a characteristic frequency in the power spectral density of the CO signal. The identical control methodology is applied to the two combustors with satisfactory results. Author

A92-16666
THE APPLICATION OF HIGH PRESSURE EJECTORS TO REACTION CONTROL SYSTEMS
P. MILLER and M. W. R. SEEL (Bath, University, England) Aeronautical Journal (ISSN 0001-9240), vol. 95, Nov. 1991, p. 297-312. Research supported by SERC and British Aerospace, PLC. refs
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A numerical analysis is conducted to ascertain the parameters which are critical to the achievement of high performance in thrust-augmenting ejectors for high-pressure reaction-control systems typical of VTOL aircraft. A novel method for the improvement of mixing in confined ejector flows is investigated experimentally for both sonic and supersonic primary flows. Performance is found to be sensitive to mixing efficiency in terms of the mixing duct exit flow's uniformity and primary nozzle losses. Attention is given to the difference in performance between underexpanded nozzles fitted with castellations and those leaving plain nozzles. O.C.

A92-16819
A METHOD FOR DETERMINING THE OPTIMAL COMPOSITION OF THE MEASURED PARAMETERS IN DIAGNOSING GAS TURBINE ENGINES [METOD OPREDELENIIA OPTIMAL'NOGO SOSTAVA IZMERIAEMYKH PARAMETROV PRI DIAGNOSTIROVANII GTD]
G. E. GRECHIKHA Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1990, p. 71-75. In Russian. refs
Copyright

An algorithm is proposed for evaluating the diagnostic value of the parameters of gas turbine engines and other linear plants. The algorithm makes it possible to determine the optimal composition of the measured parameters for specified diagnostic conditions. The diagnostic value of a given parameter is determined as the difference of the amount of the useful information and the noise introduced by the measured parameter. V.L.

A92-16828
EFFECT OF EULERIAN INERTIA FORCES ON THE STRESSED STATE OF THE ROTATING COMPONENTS OF AIRCRAFT TURBOMACHINES [VLIIANIE EILEROVYKH SIL INERTSII NA NAPRIAZHENNOE SOSTOIANIE VRASHCHAIUSHCHIKHSIA DETALEI TURBOMASHIN LA]
A. IU. DRONNIK Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1990, p. 99-102. In Russian. refs
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The effect of Eulerian inertia forces on the rotating parts of powerplant turbines in flight is investigated analytically. It is shown, in particular, that stresses generated by Eulerian inertia forces in the rotating parts of the turbines vary from several percent to a few tens of percent of the permissible stress. The resulting stresses are superposed on the nearly ultimate tensile and bending stresses generated by the centrifugal and gas pressure forces. An illustrative example is presented. V.L.

A92-16831
EFFECT OF THE BLADE HEIGHT OF THE NOZZLE RING OF AXIAL-FLOW MICROTURBINES ON THE FLOW VELOCITY FACTOR AND EXIT ANGLE [VLIIANIE VYSOTY LOPATOK SOPLOVOGO APPARATA OSEVYKH MIKROTURBIN NA KOEFFITSIENT SKOROSTI I UGOL VYKHODA POTOKA]
N. T. TIKHONOV and E. E. PFAIFLE Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1990, p. 107-109. In Russian. refs
Copyright

The effect of the blade height of the nozzle ring on the flow velocity factor and exit angle of microturbines was investigated experimentally using six nozzle rings with blade heights of 0.5, 1, 2, 3, 4, and 5 mm. It is found that the flow exit angle increases continuously with the relative height of the nozzle ring blades. The flow velocity factor increases significantly (from 0.845 to 0.925

at Mach 1.8) as the relative blade height increases from 0.01 to 0.04. With a further increase in the blade height from 0.04 to 0.07, the velocity factor increases to a lesser extent (from 0.925 to 0.94 at Mach 1.8). V.L.

A92-17176
AERATING FUEL NOZZLE DESIGN INFLUENCES ON AIRFLOW FEATURES
T. J. ROSFJORD (United Technologies Research Center, East Hartford, CT) and W. A. ECKERLE (Cummins Engine Co., Columbus, IN) Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, Nov.-Dec. 1991, p. 849-856. Research supported by United Technologies Corp. Previously cited in issue 18, p. 3004, Accession no. A88-44765. refs
(Contract F33615-85-C-2515)
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A92-17177
REVIEW OF PROPULSION APPLICATIONS AND NUMERICAL SIMULATIONS OF THE PULSED DETONATION ENGINE CONCEPT
S. EIDELMAN, W. GROSSMANN, and I. LOTTATI (Science Applications International Corp., McLean, VA) Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, Nov.-Dec. 1991, p. 857-865. Research supported by DARPA. Previously cited in issue 20, p. 3090, Accession no. A89-46837. refs
(Contract N66001-88-D-0088)

A92-17179
THERMAL IMAGING OF AFTERBURNING PLUMES
E. GUTMARK, T. P. PARR, K. J. WILSON, K. C. SCHADOW (U.S. Navy, Naval Weapons Center, China Lake, CA), and E. AJDARI *Journal of Propulsion and Power* (ISSN 0748-4658), vol. 7, Nov.-Dec. 1991, p. 873-878. Previously cited in issue 09, p. 1343, Accession no. A89-25055. refs

A92-17200
JET ENGINE FAULT DETECTION WITH DISCRETE OPERATING POINTS GAS PATH ANALYSIS
A. STAMATIS, K. MATHIOUDAKIS, K. PAPAILIOU (Athens, National Technical University, Greece), and G. BERIOS (International Symposium on Air Breathing Engines, 9th, Athens, Greece, Sept. 3-8, 1989, Proceedings. Volume 2, p. 1244-1250) Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, Nov.-Dec. 1991, p. 1043-1048. Previously cited in issue 02, p. 153, Accession no. A90-12633. refs
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A92-17202
ENGINEERING MODEL FOR ANALYSIS OF SCRAMJET COMBUSTOR PERFORMANCE WITH FINITE-RATE CHEMISTRY
MARIA V. PULSONETTI, JOHN ERDOS, and KEVIN EARLY (General Applied Science Laboratories, Inc., Ronkonkoma, NY) *Journal of Propulsion and Power* (ISSN 0748-4658), vol. 7, Nov.-Dec. 1991, p. 1055-1063. Research supported by Pratt and Whitney Group and USAF. Previously cited in issue 19, p. 3181, Accession no. A88-46501. refs
Copyright

A92-17203
ISOTHERMAL MODELING OF GAS TURBINE COMBUSTORS - COMPUTATIONAL STUDY
P. KOUTMOS and J. J. MCGUIRK (Imperial College of Science, Technology, and Medicine, London, England) Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, Nov.-Dec. 1991, p. 1064-1071. Research supported by Ministry of Defence of England. refs
Copyright

Computations have been conducted for the swirl-driven recirculation flow of a swirl-stabilized tuboannular gas turbine combustor under isothermal conditions. The combustor geometry is split into two zones; the flow in the exit nozzle is computed on the basis of a general method for complex geometries. Numerical model performance is assessed in view of LDA measurements of the velocity and turbulence fields. Discrepancies between predictions and measurements are noted to increase in the dilution region, and the predicted levels of turbulence energy are too low in regions of high anisotropy. Global aspects of isothermal flows were found to be representable with acceptable accuracy for preliminary-design purposes. O.C.

N92-11996# Toronto Univ. (Ontario). Inst. for Aerospace Studies.
AN EXPERIMENTAL AND COMPUTATIONAL INVESTIGATION OF AN ANNULAR REVERSE-FLOW COMBUSTOR
T. C. J. HU, R. A. CUSWORTH, and J. P. SISLIAN Nov. 1990 280 p Sponsored in part by National Science and Engineering Research Council
(UTIAS-338; ISSN-0082-5255; CTN-91-60253) Avail: NTIS HC/MF A13

The complex flowfield of a Pratt and Whitney Canada toroidal vortex annular reverse flow sector combustor was investigated. The longitudinal or instantaneous velocity and transverse velocity components of the mean velocity and the corresponding turbulence intensities (mean longitudinal stress, mean transverse stress and mean shear stress) were mapped in detail for cold flow with and without fuel injection and hot flow conditions, with a two component argon-ion laser Doppler velocimeter (LDV) operated in dual beam, forward scatter mode. The flowfield characteristics were identified from the LDV data and the flow visualization pictures substantiated the findings. Effects of heat addition on the flowfield were determined from comparisons of the cold and hot flows. Results show that combustion intensifies vortical and recirculating flows, increases the momentum of the fuel jet, locally laminarizes the fuel jet near the injector inlet, and increases the turbulence kinetic energy and turbulent stresses at the shear layers. The combustor aerodynamic developments in the flowfield with and without fuel injection are discussed. Predictions of the cold flow using a 2-D TEACH-type computer code demonstrated that the code can provide qualitative agreement for flow regions which are not strongly 3-D in nature, where a 3-D numerical model is required in resolving all the flow features realistically. Author (CISTI)

N92-11997# National Research Council of Canada, Ottawa (Ontario). Structures and Materials Lab.
NUMERICAL VERIFICATION OF NISA 2 FINITE ELEMENT ANALYSIS OF THE CRACKED 5TH STAGE COMPRESSOR DISC OF J-85 JET ENGINE
J. J. KACPRZYNSKI Sep. 1990 163 p Sponsored in part by Hawkwer Siddeley Canada Ltd.
(Contract FA220787NRC06; IAR PROJ. 07335)
(NRC-LTR-ST-1792; CTN-91-60258) Copyright Avail: NTIS HC/MF A08

In practical damage tolerance analyses of jet engines, a simple, reliable, accurate, fast finite element code with good pre- and post-processing capability and with a full 3-D fracture mechanics capability, is required. The general finite element code NISA II and its fracture mechanics module ENDURE are considered as a potential candidate for this kind of analysis. In order to verify the correctness of the code, a novel approach has been adopted. After some initial tests of NISA II, the ABAQUS finite element model of the disc was manually changed to the NISA form. Hence the NISA II model is identical to the ABAQUS model, and it uses the same type of elements. Numbering of nodes and elements are also identical. This provides the opportunity to identify and analyze any discrepancy in the results. A three dimensional finite element analysis of the cracked 5th stage compressor disc of the J-85 jet engine was performed with NISA II, version 89, and compared against two detailed analyses performed with ABAQUS. Second order solid elements were used with wedges at the crack tip. The quarter point middle node location was used to represent the singularity at the crack tip. NISA II produced nearly identical crack opening displacements as ABAQUS. ENDURE, version 90 - NISA II fracture mechanics module, did not allow for a general 3-D fracture mechanics analysis; therefore, the stress intensity factors were calculated with ABAQUS only. CISTI

N92-11998# National Research Council of Canada, Ottawa (Ontario). Engine Lab.
HUMIDITY EFFECTS ON GAS TURBINE PERFORMANCE
W. GRABE and J. BIRD Dec. 1988 44 p
(NRC-30241; NRC-TR-ENG-003; CTN-91-60285) Avail: NTIS HC/MF A03

Problems arising from natural moisture in the inlet air of gas turbine engines have been addressed. A study of open literature has identified two separate areas of concern: condensation taking place in the air intake, and performance changes arising from humidity effects on gas properties. A brief review of the elements of moist air was given. It was established that condensation depends on a complex combination of relative humidity, air temperature, inlet Mach number, and residence (dwell) time. Operational limits for humidity have been suggested. Two correction approaches for humidity effects on major engine parameters were investigated, one by Samuels and Gale and the other by Fishbeyn and Pervyshin. The correction factors of the two methods had the same trends and nearly the same magnitude for each parameter. It has been proposed that the correction system by Fishbeyn and Pervyshin be implemented for all gas turbine performance testing. These corrections can be of the order of 0.1 to 0.8 percent for high humidity test conditions. Author (CISTI)

N92-11999# National Research Council of Canada, Ottawa (Ontario). Engine Lab.
PRELIMINARY ANALYSIS OF BASELINE VIBRATION DATA FROM ALLISON T56-A-14LFE ENGINE AND REDUCTION GEARBOX
J. M. MCDOUGALL, J. NICKS, and G. KRISHNAPPA Dec. 1988 79 p
(NRC-31578; NRC-TR-ENG-013; CTN-91-60298) Copyright Avail: NTIS HC/MF A05

One of the major activities of the National Research Council Canada (NRC) Engine Laboratory is condition monitoring of mechanical components in gas turbine engines by vibration analysis. These components include gears, bearings, shafts, and couplings. Failure of any of these components can be catastrophic, especially in the case of helicopter gearboxes. An Allison T56-A-14LFE turbo-prop gas turbine engine is used as the experimental engine, but the ultimate application is the F404 engine. The program on the T56 engine consists of gathering baseline data to detect component visibility, that is, the ability to discern signals produced by individual bearings and gears from the overall signal picked up by the transducer. This report contains the preliminary analysis on baseline data recorded from the T56-A-14LFE engine. From the results of visibility tests, monitoring locations and methods were selected for each mechanical component. Only the components in the engine (power section) and the power train in the reduction gearbox were monitored. This report describes the monitoring methods, test procedures, and details of the techniques of signal analysis using the Mechanical Systems Diagnostic Analyzer. The signatures of all the gears, with the exception of the compressor extension shaft bevel gear, could be seen. Since all of the bearings were in good condition, their visibility could not be definitively established.
CISTI

N92-12000# National Research Council of Canada, Ottawa (Ontario). Engine Lab.
FUEL FLOW MEASUREMENT IN GAS TURBINE TESTING
W. GRABE Aug. 1988 49 p
(NRC-29808; NRC-TR-ENG-001; CTN-91-60303) Copyright Avail: NTIS HC/MF A03

The accurate measurement of fuel flow constitutes an important part of gas turbine performance assessment. Prompted by an international engine testing program, and the mandate to improve all aspects of gas turbine performance evaluation, the Engine Laboratory of the National Research Council of Canada has critically examined the existing fuel flow measuring methods. The report describes all elements of the fuel flow measuring system in detail, with source documentation wherever possible. Since the laboratory employs turbine flowmeters exclusively, the discourse has been limited to that type of flow establishment. Together with an in-house ballistic flowmeter calibrator, and an up-to-date data acquisition and reduction computer system, the present Engine Laboratory fuel flow measuring system provides gas turbine fuel flow assessment of known accuracy. An error analysis, for normal operating conditions, indicated an uncertainty in corrected fuel flow of minus/plus 75 percent. Recommendations have been made for improvements in some measurement components.
Author (CISTI)

N92-12001# National Research Council of Canada, Ottawa (Ontario). Engine Lab.
A DERIVATION OF GROSS THRUST FOR A SEA-LEVEL JET ENGINE TEST CELL
JAMES D. MACLEOD Sep. 1988 78 p
(NRC-30165; NRC-DM-009; CTN-91-60304) Copyright Avail: NTIS HC/MF A05

For accurate, indoor ground-level testing of jet engines, the influence of the test cell on the thrust produced by the engine must be established. The true gross thrust may be derived from the measured scale force, if the aerodynamic conditions inside the test cell are known. The test cell effect may also be quantified using correlation factors determined from comparison of test data taken from indoor facilities, and reference outdoor of free-air test stands. In this report, the influence of the test cell on engine performance is described. The forces measured in a particular indoor test cell are derived, and a comparison of actual test data from an indoor test cell to an outdoor test stand is made. The results show that if all the aerodynamic forces have been accounted for, which in this case require corrections of up to 2 percent, the corrected thrust in an indoor cell is the true gross thrust.
Author (CISTI)

N92-13069# General Electric Co., Fairfield, CT.
GAS TURBINE ENGINE CONTROL Patent
RONALD S. CARPENTER, inventor, FREDERICK J. PINEO, inventor, and WILLIAM L. GAZZOLA, inventor 25 Sep. 1990 12 p
(PATENT-1-274-606; INT-PATENT-CLASS-G10L-914; INT-PATENT-CLASS-G10L-908; CTN-91-60235) Copyright Avail: Micromedia Ltd., Technical Information Centre, 165 Hotel de Ville, Place du Portage, Phase 2, Hull, Quebec J8X 3X2, Canada HC $4.00 CAN, MF $2.75 CAN

An invention is presented which relates to a thrust droop compensator designed to improve gas turbine engine control. Such a compensator reduces the droop in thrust which sometimes occurs because of different rates of thermal growth of various engine components during engine acceleration. This compensator consists of a gas engine control which modulates a variable exhaust nozzle as a function of parameters which include a temperature error signal.
CISTI

N92-13071*# Sverdrup Technology, Inc., Brook Park, OH.
UNSTEADY BLADE PRESSURES ON A PROPFAN AT TAKEOFF: EULER ANALYSIS AND FLIGHT DATA Final Report
M. NALLASAMY Nov. 1991 12 p *Presented at the 30th Aerospace Sciences Meeting and Exhibit, Reno, NV, 6-9 Jan. 1992; sponsored by AIAA*
(Contract NAS3-25266)
(NASA-CR-189076; E-6706; NAS 1.26:189076; AIAA-92-0376) Avail: NTIS HC/MF A03 CSCL 21/5

The unsteady blade pressures due to the operation of the propfan at an angle to the direction of the mean flow are obtained by solving the unsteady three dimensional Euler equations. The configuration considered is the eight bladed SR7L propfan at takeoff conditions and the inflow angles considered are 6.3 deg, 8.3 deg, 11.3 deg. The predicted blade pressure waveforms are compared with inflight measurements. At the inboard radial station ($r/R = 0.68$) the phase of the predicted waveforms show reasonable agreement with the measurements while the amplitudes are over predicted in the leading edge region of the blade. At the outboard radial station ($r/R = 0.95$), the predicted amplitudes of the waveforms on the pressure surface are in good agreement

with flight data for all inflow angles. The measured (installed propfan) waveforms show a relative phase lag compared to the computed (propfan alone) waveforms. The phase lag depends on the axial location of the transducer and the surface of the blade. On the suction surface, in addition to the relative phase lag, the measurements show distortion (widening and steepening) of the waveforms. The extent of distortion increases with increase in inflow angle. This distortion seems to be due to viscous separation effects which depend on the azimuthal location of the blade and the axial location of the transducer. Author

N92-13072# Naval Postgraduate School, Monterey, CA.
FURTHER CALCULATIONS OF THE PERFORMANCE OF TURBOFAN ENGINES INCORPORATING A WAVE ROTOR M.S. Thesis
JAMES W. ROBERTS Sep. 1990 107 p
(AD-A240867) Avail: NTIS HC/MF A06 CSCL 21/5

Two recent computer programs, WRCOMP and ENGINE, by A. Mathur, were used to examine the performance to be gained by incorporating a wave rotor component in a turbofan engine with mixed exhausts. The programs were transferred to a VAX-2000 computer, extended, and test cases reported by A. Mathur were successfully reproduced. A comparison was made between ENGINE, in which real gas effects are accounted for, and ONX (by J. Mattingly) in which constant specific heats are used. The inclusion of real gas effects proved to have a significant impact on the predicted performance. An extension of Mathur's results was made by varying the overall pressure ratio in the wave-turbofan engine. Further cycle studies and experiments to measure wave rotor component performance are recommended. GRA

08

AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

A92-13693
MODAL IDENTIFICATION IN THE PRESENCE OF STEADY EXCITATION [DIE MODALE IDENTIFIKATION BEI UNBEKANNTER STATIONAERER ZUFALLSERREGUNG]
A. SCHENK (DLR, Institut fuer Aeroelastik, Goettingen, Federal Republic of Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 15, Oct. 1991, p. 300-310. In German. refs
Copyright

A method for solving problems involving unknown excitation with a steady randomlike time history is proposed. The method combines the Random Decrement Technique and an extended Ibrahim Time Domain algorithm. The theory of the method is discussed in detail and practical applications to flight variation tests are examined. Results from simulated time histories and experimental flight data are presented. C.D.

A92-13696
FLIGHT IN A STEADY WIND FIELD [FLUG IM STATIONAEREN WINDFELD]
J. J. BUCHHOLZ (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) and J. RUSSOW (Mercedes-Benz AG, Sindelfingen, Federal Republic of Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 15, Oct. 1991, p. 323-326. In German.
Copyright

Some interesting flight-mechanical relationships which occur in flight in a steady wind field are examined. General questions which are encountered in simulations of such flight situations and in the estimation of wind or other aerodynamical states are addressed. C.D.

A92-14027
DEVELOPMENT AND FUTURE VIEW OF THE TECHNOLOGY FOR FLY-BY-LIGHT CONTROL SYSTEM ELEMENTS
MITSUYOSHI MAYANAGI Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 39, no. 452, 1991, p. 450-457. In Japanese. refs

Development of the technology for fly-by-light control systems is reviewed. The optical sensor and optical data bus are discussed and their performance features are listed. Flight test results are reported. Y.P.Q.

A92-14334
FLYING QUALITIES EVALUATION OF THE V22 TILTROTOR
C. DABUNDO, J. WHITE (Boeing Defense and Space Group, Helicopters Div., Philadelphia, PA), and M. JOGLEKAR (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 109-121. refs
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Flight testing of the V22 has been ongoing since first flight on March 19, 1989. This paper presents an overview of the flying qualities evaluation and development of the V22. Government evaluations of the V22, which have demonstrated the aircraft's mission potential for ground and sea based operations, are discussed. Results include testing of the Primary Flight Control System (PFCS) and the Automatic Flight Control System (AFCS). These results show that the V22 is in compliance with the applicable military specifications for flying qualities. Author

A92-14335
HANDLING QUALITIES OF THE H-76 FANTAIL DEMONSTRATOR
GREGORY P. WRIGHT, JOSEPH T. DRISCOLL (Sikorsky Aircraft, Stratford, CT), and JOSEPH D. NICKERSON, JR. (Boeing Defense and Space Group, Helicopters Div., Philadelphia, PA) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 123-135. refs
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The results of handling qualities-related design efforts and validation tests are evaluated for the H-76 helicopter's 'Fantail' tail-rotor/empennage/directional control systems demonstrator and flight-test vehicle. Attention is given to the evolution of the fan's mathematical model, whose use in simulations supported the assessment of such design considerations as fan scaling, horizontal and vertical stabilizer design, vertical tail incidence selection for fan unloading in forward flight, and optimization of horizontal location to minimize main rotor wake impingement effects. O.C.

A92-14336
IDENTIFICATION OF HIGHER-ORDER HELICOPTER DYNAMICS USING LINEAR MODELING METHODS
BIMAL L. APONSO, DONALD E. JOHNSTON, WALTER A. JOHNSON, and RAYMOND E. MAGDALENO (Systems Technology, Inc., Hawthorne, CA) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 137-153. refs
(Contract N00019-87-C-0195)
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The higher-order dynamics of the helicopter is dominated by rotor and structural modes. Accurate modeling of these higher-order dynamics is essential if high bandwidth, robust control systems are to be implemented in modern helicopters. An analytically based, higher-order linear model has been developed and compared with frequency domain flight data for a Sikorsky CH-53E helicopter at hover. Flight test data showed the helicopter to be remarkably linear in its responses. The linear model proved capable of modeling the higher-order dynamics of the helicopter with an adequate degree of accuracy. Correlation between the model and flight data for the cyclic responses was improved by adjusting model parameters specific to the rotor lag degree-of-freedom. This indicated that the rotor lag degree-of-freedom dynamics were

different to that predicted by theory. The model was used to identify the dominant higher-order modes in the helicopter responses. Author

A92-14337* *Maryland Univ., College Park.*
FORWARD FLIGHT TRIM CALCULATION AND FREQUENCY RESPONSE VALIDATION OF A HIGH-ORDER HELICOPTER SIMULATION MODEL
FREDERICK D. KIM, ROBERTO CELI (Maryland, University, College Park), and MARK B. TISCHLER (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 155-168. Research supported by U.S. Army. refs
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This paper describes a new trim procedure, that includes the calculation of the steady-state response of the rotor blades, and that is applicable to straight flight and steady coordinated turns. This paper also describes the results of a validation study for a high order linearized model of helicopter flight dynamics, that includes rotor, inflow, and actuator dynamics. The model is obtained by numerical perturbations of a nonlinear, blade element type mathematical model. Predicted responses are compared with flight test data for two values of flight speed. The comparison is carried out in the frequency domain. Numerical simulations show that the trim algorithm is very accurate, and preserves the periodicity of the aircraft states. The results also indicate that the predictions of the linearized model are in good agreement with flight test data, especially at medium and high frequencies. Author

A92-14338* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
HELICOPTER CONTROL RESPONSE TYPES FOR HOVER AND LOW-SPEED NEAR-EARTH TASKS IN DEGRADED VISUAL CONDITIONS
CHRISTOPHER L. BLANKEN, DANIEL C. HART (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA), and ROGER H. HOH (Hoh Aeronautics, Inc., Lomita, CA) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 169-193. refs
Copyright

The NASA-Ames Vertical Motion Simulator and Dig 1 Computer Image Generator (CIG) have been used to simulate a helicopter cockpit in a degraded visual environment in order to assess several control-response types during low-level flight. CIG visibility was reduced to the point where the horizon and other far-field cues were indiscernible. The control-response types encompassed a rate command, an attitude command/hold, and a translational rate command; piloting tasks were hover, vertical landing, a pirouette, acceleration/deceleration, and a sidestep maneuver. Visual cue ratings with a rate-command response type were initially collected to set the usable cue environment at 3. A rate-command response type provided poor Level 2 handling qualities. O.C.

A92-14340
PRACTICAL ROBUSTNESS TESTING FOR HELICOPTER FLIGHT CONTROL SYSTEMS
STEPHEN OSDER and DONALD CALDWELL (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 209-221. refs
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Tests which may be used to verify that the solutions obtained by helicopter flight-control systems are robust in the presence of the nonlinear and highly coupled dynamics that are representative of current helicopters are presented. Systems designed with full-state feedback methodologies, while satisfying 'singular value' criteria, may fail when real nonlinearities and realistic plant and control-matrix variations are introduced. The design procedure is based on a physically intuitive decoupling method which converts the helicopter MIMO problem into a sequence of SISO loops. This yields an explicit, high-gain model-following system. O.C.

A92-14380
DEVELOPMENT TESTING OF THE EH101 FLIGHT CONTROL SYSTEM
ROMAN MURYN (Westland Helicopters, Ltd., Yeovil, England) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 733-745.
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The newly developed high-integrity Flight Control System for the EH101 helicopter is of dual lane, multiprocessor configuration, which in conjunction with a multisensor architecture provides excellent failure survival characteristics. The system requirements were evolved and validated with the use of a vision and motion simulator for control law design, and extensive rig facilities for system design and development. Details of the development process are described. Author

A92-14400
DYNAMIC RESPONSE OF A VARIABLE-SPEED ROTOR DURING RAPID SHAFT TILT
ANDREW S. ELLIOTT (Mechanical Dynamics, Inc., Ann Arbor, MI) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 1029-1043. refs
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The dynamic responses of five-bladed, articulated rotor undergoing translational accelerations, rapid changes in rotor speed and large pylon tilts are examined analytically using an extended general-purpose mechanical system simulation code. All nonlinear geometric and kinematic coupling effects are retained in the analysis. Aerodynamic forces on the rigid rotor blades are generated using two-dimensional, quasi-steady strip theory and enhanced table lookup. An autopilot-like automatic controller is used to obtain commanded thrust and hub moments, and to maintain desired rotor speeds. The necessary controller equations are appended directly to the structural equations and integrated simultaneously. The combined effects of forward velocity and acceleration, rotor speed and deceleration, tilt and tilting rate on the overall system response have been computed over a range of flight conditions for a lightly loaded rotor. Selected results are presented, demonstrating the advantages and problems of this computational approach to rotor system analysis. Author

A92-14405
V-22 THRUST POWER MANAGEMENT CONTROL LAW DEVELOPMENT
JOSEPH SCHAEFFER, ROGER ALWANG (Boeing Defense and Space Group, Helicopters Div., Philadelphia, PA), and MUKUND JOGLEKAR (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 1093-1100. refs
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This paper addresses the thrust power management system (TPMS) design for the V-22 tiltrotor aircraft and discusses the development process through flight test demonstration. An overview of the TPMS structure, which forms an integral part of the Primary Flight Control System, is presented, including basic requirements for the control and overall system design approach. Control laws for maintaining rotor RPM and means for establishing engine power demand are described. Development from preliminary design concepts to the flight test article is discussed with descriptions of the analytical methodology used in achieving system goals. Finally, specific flight test results validating the design are presented. Author

A92-14421
ENHANCED ENERGY MANEUVERABILITY FOR ATTACK HELICOPTERS USING CONTINUOUS, VARIABLE (C-V) ROTOR SPEED CONTROL
CARL G. SCHAEFER, JR. (U.S. Navy, Naval Air Systems Command, Washington, DC) and FREDERICK H. LUTZE, JR. (Virginia Polytechnic Institute and State University, Blacksburg) IN:

AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 1293-1303. refs
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The present paper outlines a concept called continuous, variable (C-V) rotor speed control in which rotor speed is continuously varied as a function of instantaneous airspeed, commanded maneuvering load factor, and the possible use of anticipatory response of cyclic and collective control throws and rates. The paper presents results of a parameter optimization study that identified several optimal C-V rotor speed control law parameters designed to improve helicopter combat effectiveness in both the ground attack and air combat missions. The results indicate that the C-V rotor control concept is a viable solution to improving the maneuverability and agility of attack helicopters. Depending on the type of C-V rotor control law chosen, this research demonstrated a 31 percent improvement in time-to-turn 180 degrees, a 38 percent improvement in turn penetration distance, a 42 percent improvement in turn cross track distance, and a pointing margin advantage of nearly 78 deg over a comparable helicopter without C-V rotor control. Author

A92-14422
V-22 PILOT-IN-THE-LOOP AEROELASTIC STABILITY ANALYSIS
TOM PARHAM, JR., DAVID POPELKA (Bell Helicopter Textron, Inc., Fort Worth, TX), DAVID G. MILLER, and ARNOLD T. FROEBEL (Boeing Defense and Space Group, Helicopters Div., Philadelphia, PA) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 1307-1319. refs
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Aeroelastic stability analyses have been correlated with pilot-in-the-loop stability data from the V-22 flight test program. In this paper, the analysis methodologies used to evaluate the aeroservoelastic stability characteristics of the Osprey are discussed, including the development of math models of pilot and control stick feedback characteristics and pertinent interactional aerodynamic effects. The pilot-in-the-loop stability analysis is refined using data from mechanical shake tests of the pilot and control stick, as well as data from inflight aeroelastic shake tests. No aeroelastic instabilities for the V-22 basic aircraft have been encountered or projected. However, several pilot-in-the-loop aeroelastic coupling mechanisms have been encountered during V-22 experimental flight tests. These are used to evaluate the predictive capability of three aeroservoelastic computer codes. The agreement of analysis with actual aircraft behavior enables definition of flight control system aeroelastic filters to be made with a high degree of confidence. Author

A92-14423
ALLEVIATION OF WHIRL-FLUTTER ON TILT-ROTOR AIRCRAFT USING ACTIVE CONTROLS
JOHANNES M. VAN AKEN (Sterling Software, Inc., Palo Alto, CA) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 1321-1344. refs

The feasibility of using active controls to delay the onset of whirl-flutter on a XV-15 size tilt-rotor aircraft was investigated. The CAMRAD/JA code was used to obtain a set of linear differential equations, which describe the motion of the tilt-rotor aircraft. The hub motions due to wing/body motion is a standard input to CAMRAD/JA and was obtained using the NASTRAN finite element structural analysis code. The CAMRAD/JA output, consisting of the open-loop system matrices, and the NASTRAN-calculated airframe free-vibration motion were input to a separate program, which performed the closed-loop, active control calculations. An eigenvalue analysis was performed to determine the flutter stability of both open- and closed-loop systems. Sensor models, based upon the feedback of pure state variables and based upon wing-mounted sensors, providing physically measurable accelerations, were evaluated. It was shown that the onset of tilt-rotor whirl-flutter could be delayed from 285 to above 300 knots by feeding back chord-wise and beam-wise accelerations, measured near the wing tip, to the longitudinal cyclic pitch. Time response calculations at a 300-knot cruise condition showed an active cyclic pitch control level of 0.011 deg., which equates to a very acceptable 10-pound active-control force applied at the rotor hub. Author

A92-14427* Maryland Univ., College Park.
DYNAMICS OF HELICOPTERS WITH DISSIMILAR BLADES
JAMES M. WANG and INDERJIT CHOPRA (Maryland, University, College Park) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 1399-1412. refs
(Contract NAG2-409)
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The dynamics of helicopters with dissimilar rotor blades is investigated for hingeless rotors in hover. An elastic blade model with finite element formulation is used. Hub motions are included by modeling the fuselage as a rigid body with pitch and roll degrees of freedom. The aeromechanical stability solution is solved in the fixed frame via Floquet theory. A parametric study of the effects of dissimilarity among blades' structural stiffness, mass, and damping on aeromechanical stability is presented. It is found that a slight reduction in the lag stiffness of one blade stabilizes the regressing lag mode instability. Author

A92-14445* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
DESCRIPTION OF A TILT WING MATHEMATICAL MODEL FOR PILOTED SIMULATION
JOSEPH J. TOTAH (NASA, Ames Research Center, Moffett Field, CA) AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Paper. 16 p. refs

A tilt-wing mathematical model that was used in a piloted six-deg-of-freedom flight simulation application is presented. Two types of control systems developed for the model - a conventional programmed-flap wing-tilt control system and a geared-flap wing-tilt control system - are discussed. The objective of this effort was to develop the capability to study tilt-wing aircraft. Experienced tilt-wing pilots subjectively evaluated the model using programmed-flap control to assess the quality of the simulation. The objective was met and the model was then applied to study geared-flap control to investigate the possibility of eliminating the need for auxiliary pitch control devices. This was performed in the moving-base simulation environment, and the vehicle responses with programmed-flap and geared-flap control were compared. P.D.

A92-15340
ANALYSIS OF CRITERIA PREDICTING THE TENDENCY OF PILOT INDUCED OSCILLATION FOR LINEAR NON-LINEAR SYSTEM
HAIQUAN XIONG (Nanjing Aeronautical Institute, People's Republic of China) and E. RIEUTORD (Lyon, Institut National des Sciences Appliquees, Villeurbanne, France) Chinese Journal of Aeronautics (ISSN 1000-9361), vol. 4, May 1991, p. 214-225. refs
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Some problems encountered in applying Smith's technique to predict the PIO tendency for nonlinear pilot-vehicle loop, are thoroughly analyzed. Subsequently, modified PIO predictable criteria are developed, in addition, to make also a certain improvement on Smith's PIO definition and PIO types. These modified criteria are applied to predict the PIO tendency of various different configurations on the variable stability aircraft NT-33 in the case of supposed nonlinearity, and predicted results are compared with the flight tests and analytical results in the case of linear hypothesis. Author

A92-16079
AIRCRAFT GROUND VIBRATION TEST BY MEANS OF FLIGHT CONTROL SURFACES
A. GRAVELLE, M. LEPART, and P. LUBRINA (ONERA, Chatillon, France) (International Forum on Aeroelasticity and Structural

Dynamics, Aachen, Federal Republic of Germany, June 3-6, 1991) ONERA, TP no. 1991-96, 1991, 7 p. refs
(ONERA, TP NO. 1991-96)

A complete modal identification method using aircraft flight control surfaces as exciters has been implemented. The excitation signals applied to several control surfaces are coherent sweep frequency signals. The measurements of the strain on the actuators shafts are used to determine the introduced forces allowing to derive the generalized masses. The method was applied first to a numerical model of a fighter aircraft, then a comparative ground vibration test of a MIRAGE 2000 aircraft has been performed by means of both the classical appropriation method and the present control surfaces excitation method. The consistency of the results obtained with the two methods is satisfactory and the control surface excitation method seems promising as far as the adaptation of the excitation can be realized for the different mode shapes.
Author

A92-16092
INTEGRATION OF FLIGHT AND CARRIER LANDING AID SYSTEMS FOR SHIPBOARD OPERATIONS
B. D. VU, T. LE MOING, and P. COSTES (ONERA, Chatillon, France) (NATO, AGARD, Symposium on Aircraft/Ship Operations, Seville, Spain, May 20-23, 1991) ONERA, TP no. 1991-113, 1991, 16 p. Previously cited in issue 19, p. 3236, Accession no. A91-45631. refs
(ONERA, TP NO. 1991-113)

A92-16621
DELIVERED WITH FEELING
HARRY HOPKINS Flight International (ISSN 0015-3710), vol. 140, Nov. 20, 1991, p. 31, 35, 38.
Copyright

An overview is presented of the Boeing 777 primary flight control system which is based on a triplex system of primary flight computers, with data flows on three independent but identical channels - right, center, and left. The flight control system is designed to retain pilot awareness through tactile means, by back-driving controls and throttle, while retaining some speed/pitch stability.
R.E.P.

A92-16623
FEELING NORMAL
HARRY HOPKINS Flight International (ISSN 0015-3710), vol. 140, Nov. 27, 1991, p. 29-31.
Copyright

A review is presented of the Boeing 777 flightdeck engineering simulator, focusing on the advanced options in cockpit-data presentation, and an assessment of the company's first FBW airliner, with a new computer architecture. The advanced concepts offered are based on three major precepts: improved pilot situation awareness through improved graphics, reduced head-down time in flight-management system operations, especially in terminal areas, and provision for gradual growth without major flightdeck changes.
R.E.P.

A92-16801
AERODYNAMIC BALANCE RANGE OF AIRCRAFT OF DIFFERENT CONFIGURATIONS [DIAPAZON TSENTROVOK LEGKIKH SAMOLETOV RAZLICHNYKH SKHEM]
A. A. BADIAGIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1990, p. 3-7. In Russian. refs
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The aerodynamic balance range of light subsonic aircraft is examined for five different configurations: the classical configuration, canard, the tailless configuration, three-surface configuration, and the tandem configuration. The effect of the fuselage and powerplant on the aerodynamic balance is neglected. Of the configurations investigated, the tandem scheme is shown to have the widest balance range, whereas the canard configuration has the smallest range.
V.L.

A92-16803
OPTIMIZATION OF THE AERODYNAMIC BALANCE AND PARAMETERS OF THE HORIZONTAL TAIL SURFACES OF THE THREE-SURFACE AIRCRAFT CONFIGURATION WITH ALLOWANCE FOR THE CAPABILITIES OF THE STABILITY AND CONTROL AUGMENTATION SYSTEM [OPTIMIZATSIIA TSENTROVKI I PARAMETROV GORIZONTAL'NOGO OPERENIIA SAMOLETA SKHEMY 'TRIPLAN' S UCHETOM VOZMOZHNOSTEI SISTEMY ULUCHSHENIIA USTOICHIVOSTI I UPRAVLIAEMOSTI]
V. P. SURIN, O. P. ZORINA, and IU. I. MAL'TSEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1990, p. 11-14. In Russian. refs
Copyright

The problem of optimizing the aerodynamic balance parameters of the three-surface configuration is formulated as a nonlinear programming problem using the integral energy maneuverability of the aircraft as the criterion. The automatic control system is represented by a static longitudinal control automaton. Solution results are presented for a hypothetic maneuverable three-surface aircraft.
V.L.

A92-16807
CONSIDERATION OF THE TIME LAG OF ENGINE PROCESSES IN THE PROBLEM OF VTOL AIRCRAFT CONTROL SYNTHESIS [UCHET INERTSIONNOSTI PROTSESSOV DVIGATELEI V ZADACHE SINTEZA UPRAVLENIIA SVVP]
A. I. BOGOMOLOV and P. K. SEMENOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1990, p. 24-28. In Russian. refs
Copyright

The problem of the synthesis of a decoupling filter for a VTOL aircraft manual control system is analyzed with allowance for the effect of the time lag of engine processes. A simple method of compensating for the time lag is proposed. The validity of the approach is demonstrated by results of a numerical simulation.
V.L.

A92-16808
CONTROL OF THE LANDING OF A FLIGHT VEHICLE IN THE GRAZING-INCIDENCE MODE [UPRAVLENIE PRIZEMLENIEM LETATEL'NOGO APPARATA V SKOL'ZIASHCHEM REZHIME]
A. I. ZOTEEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1990, p. 28-33. In Russian. refs
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A nonlinear law is proposed for controlling the motion of a flight vehicle at the stage of landing. The control law is synthesized on the basis of force control in a class of piecewise continuous functions with discontinuities of the first kind. The control law provides for motion along a specified trajectory in the grazing-incidence mode.
V.L.

N92-12003# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Helicopter Div.
RESONANCE AND CONTROL RESPONSE TESTS USING A CONTROL STIMULATION DRIVE
HUBERT MUELLER and ALFRED GRUENEWALD 8 Oct. 1990 11 p Presented at the National Technical Specialists Meeting of the American Helicopter Society, Scottsdale, AZ, 8-12 Oct. 1990 Previously announced in IAA as A91-31292
(MBB-UD-0586-90-PUB; ETN-91-90194) Avail: NTIS HC/MF A03

The main functions of the STIMULI system currently used for ground and flight testing of the BO 108 are discussed. The control stimulation device was installed for better performance of ground and flight tests. Many types of collective or cyclic inputs can be chosen in a computer menu. It is possible to select the longitudinal and lateral control signals separately or in combination. Each input is of an accuracy which no pilot can reproduce. Hence ground and flight testing can be performed at a higher level of efficiency. The various applications of computer controlled main rotor inputs are demonstrated. For comparison, helicopter testing done with manual control inputs is also shown.
ESA

N92-12004# Royal Aerospace Establishment, Bedford (England).
APPLICATION OF EIGENSTRUCTURE ASSIGNMENT TO THE CONTROL OF POWERED LIFT COMBAT AIRCRAFT
P. R. SMITH 19 Feb. 1991 304 p
(RAE-TM-FS-1009; BR302867; ETN-91-90294) Copyright Avail: NTIS HC/MF A14

An examination of the eigenstructure assignment control law design technique, and its application to both a vectored thrust aircraft, and a helicopter example is reported. In reviewing the design method, new insight is shed upon the role of the left eigenvectors, which are shown to determine the nature of the input coupling into a dynamic system. It is concluded that selection of the right eigenvectors alone, as is often shown in the literature, is insufficient to ensure decoupling in the system response. Examination of the frequency domain characteristics of a helicopter example are considered, which allow the controlled aircraft handling qualities to be determined. It is shown that simple dynamic elements in the command path can be used to tune the response when problems in obtaining a sufficienctly high bandwidth are encountered. It is concluded that the method provides a viable approach to aircraft control law design, a chief attraction being the very simple structure of the resulting control laws. ESA

N92-12458# Sener Ingenieria y Sistemas S.A., Madrid (Spain).
A METHODOLOGY FOR SOFTWARE SPECIFICATION AND DEVELOPMENT BASED ON SIMULATION
G. FERNANDEZDELAMORA, R. MINGUEZ, S. KHAN, and J. R. VILLA *In* AGARD, Software for Guidance and Control 5 p Sep. 1991
Copyright Avail: NTIS HC/MF A11; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The methodology is discussed which is presently used for specification and development of guidance and control software (GCS) referred to as the phased approach. This methodology is shown to present basic shortcomings in relation with the requirements specification phase: long development time, reverse engineering tasks, and inadequate handling of errors. In order to solve these problems, a new methodology, the simulation based approach, is presented. This new methodology is based on the fact that any requirements specification for control software is preceded by a simulation task, that includes the design, code, and test of the GCS. As a consequence, the GCS is developed twice, once in the simulation, and then in the flight software. The new methodology proposed to build the GCS only once, and through the use of two basic tools: simulation and rapid prototyping, cuts through the main shortcomings of the phased approach. Author

N92-12466# Royal Aerospace Establishment, Bedford (England). Flight Systems Dept.
THE DEVELOPMENT OF A REQUIREMENT SPECIFICATION FOR AN EXPERIMENTAL ACTIVE FLIGHT CONTROL SYSTEM FOR A VARIABLE STABILITY HELICOPTER: AN ADA SIMULATION IN JSD
GARETH D. PADFIELD, STEPHEN P. BOWATER, ROY BRADLEY, and ALAN MOORE (LBMS Proprietary Ltd. Co., London, England) *In* AGARD, Software for Guidance and Control 13 p Sep. 1991
Copyright Avail: NTIS HC/MF A11; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

In the field of helicopter flight control and handling qualities, the potential benefits offered by Active Control Technology (ACT) are considerable. The described ATC system include full authority fly by wire actuation and fail-operate/fail-safe hardware architecture. The impact of the required functionality on the systems requirements dictated a need for a precise yet versatile specification of the system, and Jackson System Development (JSD) was selected as a design method since it provides a formal modeling of the pilot interface, and also operates at a sufficient level of detail necessary to ensure completeness and resolution of ambiguities. Author

N92-13073*# Washington Univ., Seattle. Dept. of Aeronautics and Astronautics.
ADVANCED ROTORCRAFT CONTROL USING PARAMETER OPTIMIZATION Semiannual Progress Report
BRETT VANSTEENWYK and UY-LOI LY 1991 71 p
(Contract NAG2-691)
(NASA-CR-189502; NAS 1.26:189502) Avail: NTIS HC/MF A04 CSCL 01/3

A reliable algorithm for the evaluation of a quadratic performance index and its gradients with respect to the controller design parameters is presented. The algorithm is part of a design algorithm for an optimal linear dynamic output feedback controller that minimizes a finite time quadratic performance index. The numerical scheme is particularly robust when it is applied to the control law synthesis for systems with densely packed modes and where there is a high likelihood of encountering degeneracies in the closed loop eigensystem. This approach through the use of a accurate Pade series approximation does not require the closed loop system matrix to be diagonalizable. The algorithm has been included in a control design package for optimal robust low order controllers. Usefulness of the proposed numerical algorithm has been demonstrated using numerous practical design cases where degeneracies occur frequently in the closed loop system under an arbitrary controller design initialization and during the numerical search. Author

N92-13075# California Univ., Los Angeles. Dept. of Mechanical Aerospace and Nuclear Engineering.
CONTROL AUGMENTED STRUCTURAL OPTIMIZATION OF AEROELASTICITY TAILORED FIBER COMPOSITE WINGS Final Report, 11 Nov. 1986 - 30 Sep. 1990
PERETZ P. FRIEDMANN and LUCIEN A. SCHMIT, JR. 18 Aug. 1991 71 p
(Contract F49620-87-K-0003)
(AD-A241464; AFOSR-91-0786TR) Avail: NTIS HC/MF A04 CSCL 01/3

The problem of control augmented structural optimization of aeroelastically tailored fiber composite wings was addressed in a series of comprehensive studies. This research culminated in the first truly integrated, practical computer program capable of treating this multidisciplinary synthesis problem by simultaneously changing structural, aerodynamic, and control type design variables for practical aircraft configurations. The effectiveness and efficiency of this integrated aeroservoelastic optimization capability was displayed by applying it to an RPV type vehicle as well as the more complex F-16 and X-29 type airplane models. In addition, within the framework of this research, a digital adaptive controller capable of suppressing flutter in composite wings under time varying flight conditions in subsonic and transonic flow was developed. This efficient analysis can be used as the basis for structural optimization studies of actively controlled composite wings in transonic flow. GRA

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RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

A92-13675
DISTURBANCE OF TRANSONIC WIND TUNNEL FLOW BY A SLOT IN THE TUNNEL WALL
S. RISTIC (Vazduhoplovnotehnicki Institut, Zarkovo, Yugoslavia) Experiments in Fluids (ISSN 0723-4864), vol. 11, no. 6, Oct. 1991, p. 403, 404. refs
Copyright

Measurements performed with a single slot in the bottom plate

of the test section of a transonic wind tunnel are presented. Holographic interferometry is used to visualize the disturbances in the external flow caused by the slot. O.G.

A92-13845
MIDIS - A MICROCOMPUTER FLIGHT DECISION SIMULATOR
ALAN F. STOKES (Illinois, University, Savoy) IN: Human resource management in aviation. Aldershot, England and Brookfield, VT, Avebury Technical, 1991, p. 107-121. Research supported by University of Illinois and USAF. refs
Copyright

A simulation tool is presented which facilitates study and training methods for pilot decision making in the cockpit. The instrumentation of the simulator is based on a common single-engine fixed-gear aircraft, and a microcomputer is designed for testing and training under various loads of work and stress. The software for Midis is based on the 'graph traverser' structure in which transitional probabilities link the nodes of branching structures. The system can thereby simulate a chain of changing circumstances in which individual nodes represent unique in-flight conditions. The Midis system can be used to study pilot decision making under stress by simulating the development of mishaps in time-critical decision-making contexts. Four experimental studies using the simulator are discussed in terms of the capabilities of the Midis system. C.C.S.

A92-14365
PERFORMANCE AND HANDLING QUALITIES CRITERIA FOR LOW COST REAL TIME ROTORCRAFT SIMULATORS - A METHODOLOGY DEVELOPMENT
J. V. R. PRASAD, D. P. SCHRAGE (Georgia Institute of Technology, Atlanta), W. D. LEWIS, and D. WOLFE IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 543-551. refs
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The establishment of a methodology for defining the performance and handling qualities acceptance criteria for selective fidelity, real time rotorcraft simulators is addressed. Within this framework, the simulator is classified based on the required task. The simulator is evaluated by separating the various subsystems (visual, motion, etc.) and applying corresponding fidelity constants based on the specific task. This methodology not only provides an assessment technique, but also provides a technique to determine the required levels of subsystem fidelity for a specific task. This approach provides a helpful tool for eliminating system suboptimization and for identifying critical research areas. Author

A92-14377* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
RECENT ROTORCRAFT AEROELASTIC TESTING IN THE LANGLEY TRANSONIC DYNAMICS TUNNEL
WILLIAM T. YEAGER, JR., PAUL H. MIRICK, MATTHEW L. WILBUR, JEFFREY D. SINGLETON, W. K. WILKIE (NASA, Langley Research Center; U.S. Army, Aerostructures Directorate, Hampton, VA), and M.-N. H. HAMOUDA (NASA, Langley Research Center; Lockheed Engineering and Sciences Co., Hampton, VA) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 687-703. refs
Copyright

Wind-tunnel testing of a properly scaled aeroelastic model helicopter rotor is considered a necessary phase in the design and development of new rotor systems. For this reason, extensive testing of aeroelastically scaled model rotors is done in the Transonic Dynamics Tunnel (TDT) located at the Langley Research Center. A unique capability of this facility, which enables proper dynamic scaling, is the use of diflourodichloromethane, or Refrigerant-12 (R-12) as a test medium. The paper presents a description of the TDT and a discussion of the benefits of using R-12 as a test medium. A description of the system used to conduct model tests is provided and examples of recent rotor tests are cited to illustrate the types of aeroelastic model rotor tests conducted in the TDT. Author

A92-15021
FLIGHT TEST CONTROL [UPRAVLENIE LETNYM EKSPERIMENTOM]
LEONID M. BERESTOV, VIL'GEL'M V. VID, VADIM V. GORIN, VALERII I. MEL'NIK, ALEKSANDR I. FAL'KOV, and VIKTOR N. IAKOVLEV Moscow, Izdatel'stvo Mashinostroenie, 1990, 144 p. In Russian. refs
Copyright

Control systems used in the testing of experimental aircraft and helicopters and also in experiments on board flying laboratories are described. In particular, attention is given to the objectives and conditions of flight testing, principal requirements for flight test control systems, and the general design of automatic control systems used in flight tests. The discussion also covers software used in computerized flight test control systems, simulations of airborne systems, and optimization of flight test conditions. V.L.

A92-15328
STUDY ON TRANSONIC CASCADE PERFORMANCE BY USE OF NEWLY BUILT FACILITY
S. KAJI, H. TAKATA, M. HIRAMOTO, Y. MACHIDA, H. FUJITA, and H. ITO (Tokyo, University, Japan) Chinese Journal of Aeronautics (ISSN 1000-9361), vol. 4, May 1991, p. 104-112.
Copyright

A blowdown transonic cascade wind tunnel has been built in the Department of Aeronautics at the University of Tokyo to verify newly introduced concepts, with particular reference to the field of turbomachine cascades. The system and operation of this facility are described in detail, and experimental cascade performances obtained with this facility are discussed together with numerical results for cascades designed on the basis of new concepts. L.M.

A92-15338
HIGH SPEED WIND TUNNEL WALL INTERFERENCE RESEARCH PROGRESS AT NANJING AERONAUTICAL INSTITUTE
QIWEI ZHANG and YIYI HUANG (Nanjing Aeronautical Institute, People's Republic of China) Chinese Journal of Aeronautics (ISSN 1000-9361), vol. 4, May 1991, p. 185-197. refs
Copyright

Some progress in high-speed wind tunnel wall interference research has been made at Nanjing Aeronautical Institute. It includes efforts in looking for better ventilated wall designs to reduce the wall interference effects and developing some wall interference assessment/correction (WIAC) procedures to assess or correct wall interference effects. The preforated wall with 60-deg inclined holes which has continuously variable porosity from zero to 9 percent and the slotted wall which has continuously variable open-area ratio from zero to 7 percent are used to lessen the wall interference in transonic and subsonic tests. Linear and nonlinear 2D WIAC procedures and 3D WIAC procedures were developed. The procedures use measured wall pressure data to correct the wall interference effects or judge whether the wall interference effects are correctable. They do not require any explicit knowledge about the wall cross-flow characteristics. They can be applied for 2D airfoil tests and 3D half or whole model tests with a variety of ventilated test section walls. Author

A92-15601
ON-LINE DISTORTION ANALYSIS SYSTEM FOR INLET-ENGINE TESTING
WAYNE K. MORTON, GLEN R. LAZALIER (Sverdrup Technology, Inc., Arnold AFB, TN), C. D. ROSE, and R. F. LAUER, JR. (Calspan Corp., Arnold AFB, TN) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 10 p. refs
(ASME PAPER 91-GT-166)

A system for 'near-real-time' distortion analysis support of aircraft turbine engine-inlet altitude testing is described. Target applications include both subscale and full-scale inlet-engine compatibility testing in wind tunnel, direct-connect, and free-jet configurations. The system digitizes analog-format, time-dependent

data and combines it with digital-format, steady-state data. A high-speed data bus and multiple array processors provide for on-line execution of complex distortion analysis algorithms to compute and display distortion indices, histograms, isobar plots, and surge margin consumption. Analysis algorithms are programmed using a high-level language (FORTRAN 77). Author

A92-15706
A UNIVERSAL TURBOPROP ENGINE DYNAMOMETER TEST CELL
D. MAINVILLE, D. MELFI, and M. WHITING (Pratt and Whitney Canada, Longueuil) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 7 p.
(ASME PAPER 91-GT-343)

Pratt and Whitney Canada produces a wide range of aircraft engines and this has led to a concerted effort to standardize any streamline its production engine test facilities. P&WC produce two very different series of turboprop engines, the PW100 with a conventional intake and exhaust arrangement and the PT6 with its reverse flow arrangement. A dynamometer test cell capable of testing both these engine series has been designed and built at Longueuil and is now in operation. The changeover from one model to the other can be carried out by an operator in less than two hours and requires no special tooling or manpower. This paper discusses the solutions developed to overcome the inherent problems of intake and exhaust arrangement, engine mounting, slave equipment requirements etc., generated by testing two very different families of engines in the same test cell coupled with the need to incorporate the efficiency and ease of operation required of a production facility. Author

A92-15713
LEAN BLOWOUT IN A RESEARCH COMBUSTOR AT SIMULATED LOW PRESSURES
G. J. STURGESS (Pratt and Whitney Group, East Hartford, CT), S. P. HENEGHAN, M. D. VANGSNESS, D. R. BALLAL (Dayton, University, OH), and A. L. LESMERISES (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 10 p. refs
(Contract F33615-87-C-2822; F33615-87-C-2767)
(ASME PAPER 91-GT-359)

A propane-fueled research combustor has been designed to represent the essential features of primary zones of combustors for aircraft gas turbine engines in an investigation of lean blowouts. The atmospheric pressure test facility being used for the investigation made it difficult to directly approach the maximum heat release condition of the research combustor. High combustor loadings were achieved through simulating the effects on chemical reaction rates of sub-atmospheric pressures by means of a nitrogen diluent technique. A calibration procedure is described, and correlated experimental lean blowout results are compared with well-stirred reactor calculations for the research combustor to confirm the efficacy of the calibration. Author

A92-15731
DEVELOPMENT OF A FREEJET CAPABILITY FOR EVALUATING INLET-ENGINE COMPATIBILITY
P. V. MAYWALD and D. K. BEALE (Sverdrup Technology, Inc., Arnold AFB, TN) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 16 p. refs
(ASME PAPER 91-GT-401)

The Arnold Engineering Development Center is installing a freejet test capability into the Aeropropulsion Systems Test Facility. The freejet will provide the capability for ground determination of turbine engine and aircraft inlet compatibility by utilizing full-scale inlets and engines as test articles in a simulated flight environment. The details of the design, installation, and projected testing capability are described for a 57-sq-ft supersonic nozzle and a 77-sq-ft subsonic nozzle. Support systems for mechanically pitching and yawing the freejet nozzles are also reported as well as the test cell hardware for capturing the freejet nozzle flow. The plans for demonstrating the freejet capability prior to its initial operational date are explained. The technology development efforts to validate and utilize the freejet test capabilities are also described. Author

A92-15737
JET ENGINE TEST SYSTEM INCLUDING EXPERT SYSTEM FOR DIAGNOSIS
K. SUZUKI, K. UMENE, and H. ISHIZAWA (Ishikawajima-Harima Heavy Industries Co., Ltd., Mizuho Aero-Engine Works, Tokyo, Japan) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 5 p.
(ASME PAPER 91-GT-408)

A jet engine test run system has been developed which enables automatic engine testing (functional and performance checks, including engine control trims). This system includes an expert system for diagnostic procedures which are the result of proper judgments based on experience and knowledge and high speed processing. In this paper, the construction and an application of the jet engine test equipment and the expert system for jet engine diagnostics are described. Author

A92-16110
RECENT DEVELOPMENT OF WIND-TUNNEL TEST TECHNIQUES AT ONERA [DEVELOPPEMENTS RECENTS DES TECHNIQUES D'ESSAI EN SOUFFLERIE A L'ONERA]
J. LEYNAERT (ONERA, Chatillon, France) (International Conference on Experimental Fluid Mechanics, Chengdu, People's Republic of China, June 17-21, 1991) ONERA, TP no. 1991-135, 1991, 20 p. In French. refs
(ONERA, TP NO. 1991-135)

The development of test techniques in ONERA wind tunnels is reviewed, with emphasis on high-subsonic and low-velocity testing. Particular attention is given to large-scale tests, the automation of facilities, the specifications of test setups, reliability problems, and the refinement of correction methods. L.M.

A92-16128
UTILIZATION OF A RESEARCH SIMULATOR FOR THE DEVELOPMENT OF NEW FLIGHT CONTROL CONCEPTS [UTILISATION D'UN SIMULATEUR DE RECHERCHE POUR LE DEVELOPPEMENT DE NOUVEAUX CONCEPTS DE COMMANDES DE VOL]
PH. GUICHETEAU (ONERA, Chatillon, France) (NATO, AGARD, Meeting on Piloted Simulation Effectiveness, Brussels, Belgium, Oct. 14-17, 1991) ONERA, TP no. 1991-161, 1991, 12 p. In French. Research supported by DRET, Service Technique des Programmes Aeronautiques, and Group for Aeronautical Research and Technology in Europe. refs
(ONERA, TP NO. 1991-161)

Studies have been performed that demonstrate the effectiveness of testing the behavior of the complete aircraft with the pilot in the loop by using a research flight simulator as soon as the preliminary design of new FCS is initiated for future aircraft. Three conceptual studies related to mission oriented control systems are presented. Testing of two of these concepts on full flight simulators illustrates the complementary roles of research and full flight simulators. R.E.P.

A92-16135
AERODYNAMIC MEASURING TECHNIQUES FOR TRANSONIC AND SUPERSONIC FLOW IN CASCADES AND TURBOMACHINES
R. GAILLARD (ONERA, Chatillon, France) (Von Karman Institute for Fluid Dynamics, Symposium on Aerodynamic Measuring Techniques for Transonic and Supersonic Flow in Cascades and Turbomachines, Rhode-Saint-Genese, Belgium, Sept. 17-19, 1990) ONERA, TP no. 1991-170, 1991, 19 p.
(ONERA, TP NO. 1991-170)

The probes used for measuring three-dimensional flows in wind tunels and turbomachine test stands are generally of small dimensions and have to operate in broad velocity, incidence, and pressure domains. The Aerodynamics Department at ONERA has

developed a special test bench that reduces the cost and makes it easier to calibrate these probes. The present paper describes the capabilities of this new test bench. Author

A92-16231
MADRID'S DOUBLE AIRPORT [EL DOBLE AEROPUERTO DE MADRID]
LUIS M. SANCHEZ (Escuela Tecnica Superior de Ingenieros Aeronauticos, Madrid, Spain) Ingenieria Aeronautica y Astronautica (ISSN 0020-1006), no. 325, 1991, p. 30-39. In Spanish.
Copyright

The development of the airport is described with specific emphasis given to the incorporation of operations at both the commercial facility and at the adjacent military base. Reference is given to the opinion of the press and local communities, but the paper focuses on the projected needs of the facilities as compared to the present operational capacities. Instrument upgrading is proposed to the level required for between 30 and 40 operations/h, and a new runway is presented for use by 1995. The 1995 runway is designed for precision approaches on a 3,700-m strip capable of 60 operations/h. Depending on the future growth of air traffic, an independent runway is tentatively proposed for the year 2000 that would give the airport the capacity for two takeoff runways and one landing runway permitting 75 operations/h. C.C.S.

A92-16653
A PROPOSAL FOR A DYNAMIC TEST PLATFORM FOR INERTIAL UNITS AND/OR GPS
BAL N. AGAMATA, DINIAR M. SHROFF (U.S. Navy, Naval Electronic Systems Engineering Center, San Diego, CA), and STAN C. MAKI (General Dynamics Corp., Space Systems Div., San Diego, CA) IN: Institute of Navigation, National Technical Meeting, 47th, Phoenix, AZ, Jan. 22-24, 1991, Proceedings. Washington, DC, Institute of Navigation, 1991, p. 371-381. refs

A dynamic test platform equivalent to a 4-axis gymbal system, in the form of a two-axis rotary mount that is attached to the tip of a boom and driven by an elevation-over-azimuth system, has been devised for inertial guidance and/or differential GPS guidance system testing. Such tests' results will furnish a gross check of precision-navigation and attitude-measurement systems, including strapdown or gimballed inertial measurement units (IMUs), attitude-determining GPS, differential GPS, and either loosely or tightly coupled IMU-GPS systems. The essential goal of testing is the optimal derivation of truth data with which the output of the unit under test is verified. A filter with excellent smoothing and noise rejection is required to decontaminate the data obtained. O.C.

A92-16830
A TEST BENCH FOR EVALUATING POWERPLANT ELECTRIZATION [EKSPERIMENTAL'NYI STEND DLIA ISSLEDOVANIIA ELEKTRIZATSII ENERGOUSTANOVOK]
G. P. POTAPOV, G. B. MURAV'EV, R. KH. SABIROV, T. A. CHAKKAEV, and A. A. ZADNEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1990, p. 105-107. In Russian. refs
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The general design, principle of operation, and main components of a test bench developed for the experimental investigation of the electrization of powerplants are described. The main components of the test bench include a burner, a fuel (propane-butane mixture) supply system, an air supply system, and instruments for the monitoring and recording of operating and electrophysical parameters. An evaluation of the performance of the test bench has demonstrated high reliability and repeatability of test results over a wide range of gasdynamic conditions. V.L.

A92-16972
TRANSITION OF GPS USER EQUIPMENT TESTING FROM YUMA PROVING GROUND TO HOLLOMAN AFB
J. J. LENZO, JR. and M. M. MILLER (USAF, Guidance Test Div., Holloman AFB, NM) IN: ION GPS-90; Proceedings of the 3rd International Technical Meeting of the Satellite Division of the Institute of Navigation, Colorado Springs, CO, Sept. 19-21, 1990. Washington, DC, Institute of Navigation, 1990, p. 689-696. refs

An overview of the testing and evaluation of the Central Inertial Guidance Test Facility (CIGTF) and the Yuma Proving Ground is given to evaluate the transfer of GPS user-equipment testing to the CIGTF. The respective capabilities for flight, rocket-sled, centrifuge, and laboratory testing are examined, with attention given to the development of the facilities at CIGTF. Simulator functions of the CIGTF laboratory stations permit both static and dynamic testing, and an advanced reference system is being developed for in-flight testing of navigation and guidance systems. The CIGTF is reported to be capable of providing all required testing and evaluation procedures for global positioning systems. C.C.S.

A92-17224
USING UNCERTAINTY ANALYSIS IN THE DEBUGGING AND QUALIFICATION OF A TURBULENT HEAT TRANSFER TEST FACILITY
HUGH W. COLEMAN, M. H. HOSNI, ROBERT P. TAYLOR, and GLENN B. BROWN (Mississippi State University, Mississippi State) Experimental Thermal and Fluid Science (ISSN 0894-1777), vol. 4, Nov. 1991, p. 673-683. refs
(Contract AF-AFOSR-86-0178; AF-AFOSR-85-0075)
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The application of detailed uncertainty analysis techniques in the debugging and qualification checks of a new turbulent heat transfer test facility is demonstrated. The data reduction equation for Stanton number is developed, and the associated uncertainty analysis is presented. The techniques used in estimation of the bias errors in the measured variables, including the effects of correlated bias errors in the measurements of several different variables, are discussed in some detail. Finally, the use of these estimates in first- and nth-order replication level checks of the experimental techniques and facility is illustrated. Author

N92-12006# Institut de Mecanique des Fluides de Lille (France).
STUDY OF INTERACTIONS ON ANEMOCLINOMETRIC SENSORS [ETUDE D'INTERACTIONS SUR SONDES ANEMOCLINOMETRIQUES]
M. PRUVOST and P. BAILLEUX 24 Sep. 1990 44 p In FRENCH
(Contract DRET-89-003-03)
(REPT-90/30; ETN-91-90110) Avail: NTIS HC/MF A03

The use of anemoclinometric sensors as measuring tools in wind tunnels is studied. The calibration of such sensors can be thrown off due to close proximity to the walls of the wind tunnel. The inaccuracies induced by these sensor/wall panel interactions can be due to local magnetic fields. Obstructions in the wind tunnel may directly affect the antenna and alter the aerodynamic behavior of the sensor. Pressure gradients within the flow may also affect the sensors. The distortions in the aerodynamic field of wind tunnels which lead to such sensor inaccuracies are studied. ESA

N92-12007*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMPUTER PROGRAMS FOR THE CALCULATION OF DUAL STING PITCH AND ROLL ANGLES REQUIRED FOR AN ARTICULATED STING TO OBTAIN ANGLES OF ATTACK AND SIDESLIP ON WIND-TUNNEL MODELS
JOHN B. PETERSON, JR. Oct. 1991 75 p
(NASA-TM-104161; NAS 1.15:104161) Avail: NTIS HC/MF A04
CSCL 14B

Two programs were developed to calculate the pitch and roll position of the conventional sting drive and the pitch of a high angle articulated sting to position a wind tunnel model at the desired angle of attack and sideslip and position the model as near as possible to the centerline of the tunnel. These programs account for the effects of sting offset angles, sting bending angles, and wind-tunnel stream flow angles. In addition, the second program incorporates inputs form on-board accelerometers that measure model pitch and roll with respect to gravity. The programs

are presented and a description of the numerical operation of the programs with a definition of the variables used in the programs is given. Author

N92-13076# General Accounting Office, Washington, DC.
AEROSPACE TECHNOLOGY: TECHNICAL DATA AND INFORMATION ON FOREIGN TEST FACILITIES
Jun. 1990 584 p
(GAO/NSIAD-90-71FS; B-235387) Avail: NTIS HC/MF A25; also available from GAO, PO Box 6015, Gaithersburg, MD 20877 HC first five copies free, additional copies $2.00

This report provides data and information collected by the General Accounting Office (GAO) on foreign government and industry investment in aerospace vehicle research and technological development efforts. The focus is on those critical or enabling technologies that could allow foreign countries to develop and build future aerospace vehicles. The report also identifies indicators for measuring foreign countries' current state of aerospace vehicle technological development and progress. The review includes France, West Germany, the United Kingdom, and Japan, since each of these countries are developing technologies for various concepts of operational aerospace vehicles to secure independent access to space and reduce the costs of launching payloads into orbit. Also included are facilities, such as wind tunnels, in The Netherlands, Belgium, Italy, and Australia because their test facilities are being used to conduct research and development of air-breathing aerospace vehicles by other countries and the European Space Agency (ESA). Information was collected on test facilities, their capabilities, and the number of people working on aerospace vehicle research and development in the countries that were included in the review. Facilities include (1) wind tunnels and shock tunnels, (2) air-breathing propulsion test cells (engine test facilities for ramjets and scramjets), (3) aerothermal test facilities, (4) aeroballistic and impact ranges, (5) advanced materials research, development, production, and fabrication laboratories, and (6) aerodynamic computation facilities (supercomputers). Cost information collected on test facilities included construction, replacement, annual operating, and, where available, user costs. J.P.S.

N92-13077# Systems Control Technology, Inc., Arlington, VA.
NEW YORK DOWNTOWN MANHATTAN (WALL STREET) HELIPORT: OPERATIONS ANALYSIS Final Report
DEBORAH J. PEISEN and ROY LOBOSCO Sep. 1991 156 p
(Contract DTFA01-87-C-00014)
(DOT/FAA/RD-91/12; REPT-91RR-12) Avail: NTIS HC/MF A08

The operational characteristics of the Downtown Manhattan Heliport, commonly known as the Wall Street Heliport, located in New York City were analyzed. Although selected for the Federal Aviation Administration (FAA)/Industry National Prototype Heliport Demonstration and Development Program in 1983, this heliport was opened in 1960. A general overview of the number of helicopter operations since 1960 and a detailed analysis of operational characteristics between 1987 and 1989, the time frame for which detailed data was available, is provided. Furthermore, the developmental history of the heliport is discussed. The analysis of the operations at the heliport is performed using data collected by the Port Authority of New York and New Jersey (PANYNJ), the owner and operator of the heliport. The parameters examined concentrate on the variations and trends in the number of operation by year, month, week, time of day, mission type, engine type, and number of passengers carried. Author

N92-13078# Wright Lab., Wright-Patterson AFB, OH.
SUSCEPTIBILITY OF A PARALLELOGRAM TYPE SKIN FRICTION BALANCE TO ROTATIONAL MOTION
R. N. DEMERS and J. E. LEUGERS Sep. 1991 15 p
(Contract AF PROJ. 2404)
(AD-A241348; WL-TM-91-326) Avail: NTIS HC/MF A03 CSCL 14/2

The Flight Dynamics Directorate at Wright-Patterson Air Force Base (WPAFB) is currently involved in skin friction research in the Mach 3 and Mach 6 High Reynolds Number Facilities (HRNF). The current instrument used to measure the shearing forces is a modified version of the NASA Langley parallelogram type skin friction balance tailored for operation in adverse thermal and dynamic environments. Although the balance has provided excellent results in both the Mach 3 and Mach 6 HRNF facilities, some concerns exist with the data at the very lowest stagnation pressures at Mach 3. At these low pressure (at P(sub os) of 80 psia) the balance and other measuring instruments experience erratic signal outputs. The concern therefore is whether the erratic behavior of the balance is due to tunnel vibration at low stagnation pressures or to aerodynamic conditions within the tunnel. A laboratory test was devised to determine at what frequency and amplitude the balance would experience erratic behavior. This report investigates the vibration test and analysis on the skin friction balance. GRA

N92-13079# Air Force Academy, CO.
A 3-DEGREE-OF-FREEDOM FLIGHT SIMULATOR EVALUATION OF UNSTEADY AERODYNAMICS EFFECTS
C. B. HARMON and WILLIAM DIETERICH Aug. 1991 81 p
(Contract AF PROJ. 2307)
(AD-A241540; FJSRL-TR-91-0002) Avail: NTIS HC/MF A05 CSCL 01/1

This report documents the delivery of a 3-degree-of-freedom flight simulator for the use of researchers in the field of unsteady aerodynamics. The software is distributed to qualified users via 3-1/2 inch high density diskette. The flight simulation was designed to be portable across programming languages and computer operating systems. It was written in the C programming language under MSDOS and subsequently ported to VAX/VMS, first in C then in Ada. The input files are identical under both operating systems and both languages. The output files are identical across these environments except for minor differences under Ada. The C source files are different only in their syntax for the use of include files. The build (make) files are different as are the binary object and executables. The documentation files are identical. GRA

N92-13080# Ballistic Research Labs., Aberdeen Proving Ground, MD.
APPLICATION OF DIGITAL MEASUREMENT TECHNIQUES TO ANALYSIS OF RANGE SHADOWGRAPHS Final Report, Jun. - Sep. 1988
RICHARD A. BEYER, ANTHONY J. KOTLAR, and MAUREEN R. BEYER Sep. 1991 29 p
(AD-A241554; BRL-TR-3271) Avail: NTIS HC/MF A03 CSCL 14/4

Range shadowgraphs have been digitized using a solid state video camera and a relatively unsophisticated personal computer-based frame grabber board. Image processing, including edge enhancement and level discrimination were used to provide data files for further analysis. A simultaneous multiparameter least squares fitting program was used to determine position and angle of the projectile in the image relative to fiducial markers. Analysis of accuracy and guidelines for future production systems are given. GRA

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ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

A92-16648
GPS FOR PRECISION APPROACHES
ROBERT LOH (FAA, Washington, DC) and YOUNG C. LEE (Mitre

Corp., McLean, VA) IN: Institute of Navigation, National Technical Meeting, 47th, Phoenix, AZ, Jan. 22-24, 1991, Proceedings. Washington, DC, Institute of Navigation, 1991, p. 321-329. refs

Aircraft precision-approach requirements are presently identified and compared with the different augmentations of the GPS. The results obtained indicate that augmented GPS is capable of nearly conforming to the requirements of the first level of precision approaches, but may entail additional verifications for autopilot-coupled approaches. It is noted that the 24-satellite constellation being proposed by the U.S. DOD does not satisfy the availability/continuity of service requirements for an area-wide satellite navigation system; the primary concern is less that of accuracy than of availability. O.C.

N92-12025*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.

REAL TIME DATA SYSTEM (RTDS)

TROY A. HEINDEL *In its* Control Center Technology Conference Proceedings p 443-465 Aug. 1991

Avail: NTIS HC/MF A99 CSCL 14B

Information is given in viewgraph form on the Real Time Data System (RTDS). The goals are to increase the quality of flight decision making, reduce and enhance flight controller training time, and serve as a near-operations technology test-bed. Information is given on the growth of RTDS; flight control disciplines; RTDS technology deployment in 1987-1989 and 1990-91; a functionality comparison of mainframes and workstations; and technology transfer activities. Author

N92-12033*# Research Inst. for Advanced Computer Science, Moffett Field, CA.

AMES LIFE SCIENCE TELESCIENCE TESTBED EVALUATION

RICHARD F. HAINES, VICKI JOHNSON, KRISTOFER H. VOGELSONG, and WALT FROLOFF (Lockheed Engineering and Sciences Co., Moffett Field, CA.) Jul. 1989 36 p

(Contract NASW-4234)

(NASA-CR-188856; NAS 1.26:188856; RIACS-TR-89-31) Avail: NTIS HC/MF A03 CSCL 14B

Eight surrogate spaceflight mission specialists participated in a real-time evaluation of remote coaching using the Ames Life Science Telescience Testbed facility. This facility consisted of three remotely located nodes: (1) a prototype Space Station glovebox; (2) a ground control station; and (3) a principal investigator's (PI) work area. The major objective of this project was to evaluate the effectiveness of telescience techniques and hardware to support three realistic remote coaching science procedures: plant seed germinator charging, plant sample acquisition and preservation, and remote plant observation with ground coaching. Each scenario was performed by a subject acting as flight mission specialist, interacting with a payload operations manager and a principal investigator expert. All three groups were physically isolated from each other yet linked by duplex audio and color video communication channels and networked computer workstations. Workload ratings were made by the flight and ground crewpersons immediately after completing their assigned tasks. Time to complete each scientific procedural step was recorded automatically. Two expert observers also made performance ratings and various error assessments. The results are presented and discussed. Author

N92-12049*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

CARS TEMPERATURE MEASUREMENTS IN A HYPERSONIC PROPULSION TEST FACILITY

OLIN JARRETT, JR., M. W. SMITH, R. R. ANTCLIFF, G. BURT NORTHAM, A. D. CUTLER, D. P. CAPRIOTTI, and D. J. TAYLOR (Los Alamos National Lab., NM.) *In* JHU, The 27th JANNAF Combustion Subcommittee Meeting, Volume 1 p 565-573 Nov. 1990

Avail: NTIS HC/MF A99 CSCL 14B

Nonintrusive diagnostic measurements were performed in the supersonic reacting flow of the Hypersonic Propulsion Test Cell 2 at NASA-Langley. A Coherent Anti-stokes Raman Spectroscopy (CARS) system was assembled specifically for the test cell environment. System design considerations were: (1) test cell noise and vibration; (2) contamination from flow field or atmospheric borne dust; (3) unwanted laser or electrically induced combustion (inside or outside the duct); (4) efficient signal collection; (5) signal splitting to span the wide dynamic range present throughout the flow field; (6) movement of the sampling volume in the flow; and (7) modification of the scramjet model duct to permit optical access to the reacting flow with the CARS system. The flow in the duct was a nominal Mach 2 flow with static pressure near one atmosphere. A single perpendicular injector introduced hydrogen into the flow behind a rearward facing step. CARS data was obtained in three planes downstream of the injection region. At least 20 CARS data points were collected at each of the regularly spaced sampling locations in each data plane. Contour plots of scramjet combustor static temperature in a reacting flow region are presented. Author

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CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

A92-13444

LIGHT METAL MATERIALS FOR AIRCRAFT STRUCTURE

TSUGIO IMAMURA (Mitsubishi Heavy Industries, Ltd., Nagoya, Japan) Japan Institute of Light Metals, Journal (ISSN 0451-5994), vol. 41, Sept. 1991, p. 623-634. In Japanese. refs

Aircraft construction materials are presented, with particular reference to the structures of the MU-2J aircraft. Various materials are examined, including 2024-T3, 7075-T6, Ti-6Al-4V alloy, and ZK60A-T5. The static and fatigue strength of the materials is examined, and the metal working and thermal treatment of the materials are discussed. Y.P.Q.

A92-13601

DAMAGE ASSESSMENT FOR COMPOSITE SMART STRUCTURES

R. M. MEASURES (Toronto, University, Downsview, Canada) IN: Review of progress in quantitative nondestructive evaluation. Vol. 9B. New York, Plenum Press, 1990, p. 1185-1198. Research supported by Ontario Laser and Lightwave Research Centre, NSERC, Ontario University Research Incentive Fund, et al. refs

Copyright

The groundwork necessary for the development of damage evaluation using structurally integrated fiber optic reticulate sensors technology for Kevlar/epoxy composite structures is presented. Consideration is given to an aircraft leading edge fiber optic damage assessment system. A combination of optical bleeding and image enhanced backlighting was employed in an extensive analysis of the dependence of the sensitivity to fracture of the treated optical fibers with respect to their orientation relative to the material reinforcing fibers in the adjacent plies and their depth location within the structure. R.E.P.

A92-14346

MECHANICS OF CURVED FIBER COMPOSITES

H. G. RAI, C. W. ROGERS, and D. A. CRANE (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 297-304. refs

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This paper investigates the effect of fiber waviness on the behavior of carbon-epoxy composites. A theoretical elastic model is developed to predict lamina modulus of elasticity as function of fiber waviness and is used in an incremental loading scheme to predict the general stress-strain response. This theoretical response is found to be nonlinear in the same fashion as the experimental,

measured response. An optical procedure is employed to determine the magnitude of fiber waviness in a current material IM6/3501-6 system. A convincing correlation is demonstrated between measured fiber waviness and the degree of waviness necessary to match the experimental stress-strain curve. Author

A92-14374
EVALUATION OF THERMOPLASTIC MATRIX COMPOSITES FOR USE IN ENERGY-ABSORBING HELICOPTER SUBFLOORS
STEPHEN M. ARNDT (Simula, Inc., Phoenix, AZ) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 653-660. refs
Copyright

The primary objective of the research conducted was to evaluate fiber-reinforced thermoplastic matrix composites for potential application in energy-absorbing helicopter subfloors. Two key elements of this study were to evaluate the energy absorption characteristics of candidate thermoplastic materials, and to evaluate five keel beam design concepts for use with a thermoplastic composite. Three fiber-reinforced thermoplastic matrix composites were investigated for energy absorption performance. Static and dynamic crush testing of tubes was conducted on the three thermoplastic material candidates and a baseline fiber-reinforced thermoset matrix composite. Thermoplastic System C was identified to have the best energy-absorbing performance based on these tests. The sine wave keel beam concept was selected as the best design for use with thermoplastic composites. These results will be used to continue the development of the thermoplastic matrix composite energy-absorbing helicopter subfloors. Author

A92-14680
METAL FIBERS AND FABRICS AS SHIELDING MATERIALS FOR COMPOSITES, MISSILES AND AIRFRAMES
JOHN J. TOON (Memtec America Corp., DeLand, FL) IN: IEEE 1990 International Symposium on Electromagnetic Compatibility, Washington, DC, Aug. 21-23, 1990, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 5-7.
Copyright

The advantages of metal fibers as shielding materials are examined including minimal alteration of base resin properties, shrinkage similar to unfilled resins, excellent abrasion and corrosion resistance (long life), and cost effectiveness. Applications of metal fibers as related to EMI/ESD (electromagnetic interference/electrostatic discharge) and lightning strike problems in composite structures are examined. The characteristics of nonwoven metallic fabrics, continuous multifilament yarns, and broken fibers are examined. It is concluded that metal fibers have the ability to solve ever-increasing shielding demands in an effective manner with current processes. They are also easily combined with many of the new engineering resins with minimal effect on resin characteristics. I.E.

A92-15070
EVALUATION OF THE FUNGICIDE PROPERTIES OF ANTIFREEZE ADDITIVES FOR JET FUELS [OTSENKA FUNGITSIDNYKH SVOISTV PROTIVOVODOKRISTALLIZATSIONNYKH PRISADOK K REAKTIVNYM TOPLIVAM]
V. B. SKRIBACHILIN, L. K. MIKHAILOVA, T. S. ONISHCHENKO, and N. I. SUROVTSEVA Khimiia i Tekhnologiia Topliv i Masel (ISSN 0023-1169), no. 11, 1991, p. 31, 32. In Russian. refs
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The objective of the study was to evaluate the fungicide properties of antifreeze additives in the two-phase system fuel-water with allowance for the accumultation of these additives in the water phase in the fuel system of aircraft. In particular, experimental results are presented for ethyl Cellosolve, tetrahydrofurfuryl alcohol, two-component additives based on methyl with ethyl Cellosolve and tetrahydrofurfuryl alcohol, and methyl Cellosolve. It is shown that water residues of the fuels systems with accumulated antifreeze possess fungicide properties and effectively inhibit the growth of microorganisms in fuel-water systems. V.L.

A92-15128* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
INTERMETALLIC AND CERAMIC MATRIX COMPOSITES FOR 815 TO 1370 C (1500 TO 2500 F) GAS TURBINE ENGINE APPLICATIONS
JOSEPH R. STEPHENS (NASA, Lewis Research Center, Cleveland, OH) IN: Metal and ceramic matrix composites: Processing, modeling and mechanical behavior; Proceedings of the International Conference, Anaheim, CA, Feb. 19-22, 1990. Warrendale, PA, Minerals, Metals, and Materials Society, 1990, p. 3-11. refs
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Revolutionary improvements in gas turbine engine specific fuel consumption and specific thrust are expected to be gained through incorporation of CMCs and of MMCs (whose intermetallic matrices are reinforced by highly refractory ceramic fibers). A status development evaluation is presented for NASA's Advanced High Temperature Engine Materials Technology Program, with a view to projections of early-21st century transport aircraft performance levels obtainable through the use of MMCs and CMCs in ultrahigh bypass turbofan engines. O.C.

A92-15169
THE MICROSTRUCTURAL STABILITY OF TIC REINFORCED RAPIDLY SOLIDIFIED AL-FE-V-SI COMPOSITE STRUCTURES
D. J. SKINNER, M. S. ZEDALIS (Allied-Signal, Inc., Morristown, NJ), W. E. FRAZIER (U.S. Navy, Naval Air Development Center, Warminster, PA), M. J. KOCZAK, and P. SAHOO (Drexel University, Philadelphia, PA) IN: Metal and ceramic matrix composites: Processing, modeling and mechanical behavior; Proceedings of the International Conference, Anaheim, CA, Feb. 19-22, 1990. Warrendale, PA, Minerals, Metals, and Materials Society, 1990, p. 535-541. Research supported by U.S. Navy. refs
Copyright

The elevated temperature properties of TiC reinforced, rapidly solidified, Al-Fe-V-Si composite alloy microstructures are examined with regard to the combined effects of silicide and carbide reinforcements on strength, modulus and coarsening response. The alloys were fabricated via an in situ gas/liquid reaction forming TiC platelets followed by rapid solidification (planar flow casting and jet casting) of the Al-Fe-V-Si + TiC alloy. The microstructure consists of TiC particles (e.g., 1-5 microns) and silicide Al13(Fe,V)3Si dispersoids (e.g., 50-80 nm) which, together, enhance the alloy's strength and stability. Excellent elevated temperature mechanical properties are realized with the superposition of 6 vol pct of TiC platelets and 27 vol pct Al13(Fe,V)3Si silicide phases. Author

A92-15202
HIGH TEMPERATURE MULTIAXIAL CREEP TESTING OF NIMONIC 115
L. W. CANDLER (Royal Aerospace Establishment, Farnborough, England) IN: Creep and fracture of engineering materials and structures; Proceedings of the 4th International Conference, Swansea, Wales, Apr. 1-6, 1990. London, Institute of Metals, 1990, p. 843-851. refs
Copyright

A high-temperature multiaxial testing facility commissioned using the nickel-base alloy Nimonic 115 is presented and the difficulties associated with this technique for testing are highlighted. This prototype testing machine was commissioned such that a variety of test conditions could be performed in axial, torsional, or multiaxial loading modes, at elevated temperatures (up to 1000 C). Ideas for a suitable specimen were taken from the design stage, developed and tested under a number of conditions. The limiting factors of the design are emphasized and hence modifications can be made to the initial design in order to develop the specimen design for use in future test programs. A technique developed for performing the actual tests is presented. The applicability of the Von Mises approach is discussed. C.A.B.

A92-15206
PREDICTION OF LONG-TERM CREEP RUPTURE PROPERTIES FOR AN ALUMINIUM ALLOY FOR AIRFRAME APPLICATIONS

R. W. EVANS, A. A. FADLALLA, B. WILSHIRE (Swansea, University College, Wales), R. I. BUTT, and R. N. WILSON (Royal Aerospace Establishment, Farnborough, England) IN: Creep and fracture of engineering materials and structures; Proceedings of the 4th International Conference, Swansea, Wales, Apr. 1-6, 1990. London, Institute of Metals, 1990, p. 1009-1016. Research supported by Ministry of Defence of England. refs
Copyright

Consideration is given to constant-stress creep curves obtained at temperatures from 373 to 463 K for the aluminium alloy, 2124-T851, a candidate material for airframe applications. By analyzing data recorded in tests having a minimum duration of only about 1000 hours, the creep and creep fracture properties for rupture lives in excess of 20,000 are predicted successfully using the Theta Projection Concept. C.A.B.

A92-15244
CORROSION DAMAGE AND REGENERATION OF ALUMINIDE COATINGS ON AIRCRAFT TURBINE BLADES
L. SWADZBA, B. FORMANEK, and A. MACIEJNY (Silesian Technical University, Katowice, Poland) IN: High temperature corrosion 2 - Advanced materials and coatings. London and New York, Elsevier Science Publishers, 1989, p. 407-412. refs
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Microanalytical investigations have been conducted on the alloying-element distributions of corrosion-induced microstructure changes during successive stages of damage in the protective layers of Ni-base alloys. While increased Cr and S contents are noted in the corrosion attack zone, the Mo-, W-, and Cr-enriched diffusion-zone microstructure remains virtually unchanged. Attention is presently given to two turbine blade airfoil-recoating methods: CVD chromoaluminization, and diffused annealing of a sprayed-on silicoaluminizing suspension. Such regeneration can regain turbine blade properties after a period of service. The criteria of surface-quality assessment and verification of the blades in successive regeneration stages are presented. O.C.

A92-15245
THERMAL BARRIER COATINGS FOR GAS TURBINE USE
D. J. WORTMAN, B. A. NAGARAJ, and E. C. DUDERSTADT (GE Aircraft Engines, Cincinnati, OH) IN: High temperature corrosion 2 - Advanced materials and coatings. London and New York, Elsevier Science Publishers, 1989, p. 433-440. refs
Copyright

The use of thermal barrier coatings on high-pressure turbine components can improve gas turbine efficiency through reduction of cooling airflow. However, the risk involved in reducing cooling airflow requires a highly reliable thermal barrier coating. This increased reliability will be achieved through several complementary approaches; material and process development, life prediction method development and engine service experience. The two processes available for deposition of thermal barrier coatings, plasma spray and physical vapor deposition, are compared, and the advantages and disadvantages of each discussed as they apply to gas turbine components. The results of bond coat material development, which has increased the thermal cycle life of plasma spray thermal barrier coatings, are presented. Improvements were achieved by: (1) the use of creep-resistant bond coat compositions and (2) overaluminiding of the bond coat. Results of engine testing of thermal barrier coatings in an environment that produces hot corrosion are also presented. Author

A92-15309
WEATHERING TEST OF AFRP COMPOSITES FOR THE APPLICATION OF HELICOPTER FUSELAGE
KOJI ITOH, YOSHIOKI FUKUI, and NAOYUKI TANAKA (Kawasaki Heavy Industries, Ltd., Aerospace Engineering Dept., Kobe, Japan) IN: Advanced composite materials - New materials, applications, processing, evaluation and databases; Proceedings of the 1st France-Japan Seminar on Composite Materials, Le Bourget, France, Mar. 13, 14, 1990. Paris, SIRPE Publishers, 1990, p. 83-88.
Copyright

An investigation is conducted of the weatherability of an aramid fiber-reinforced polymer (AFRP) composite intended for helicopter airframe application. The weathering tests encompassed salt-spraying, accelerated exposure, and ocean-atmosphere weathering, as well as immersion in various fluids. The flexure strength of uncoated AFRP (Nomex honeycomb-cored) sandwich panels is severely degraded by the ocean-atmosphere environment. Polyurethane coatings and a liminated polyfluorovinyl film are found to be effective protection for AFRP. O.C.

A92-15542
NICKEL BASE ALLOY GTD-222 - A NEW GAS TURBINE NOZZLE ALLOY
D. W. SEAVER and A. M. BELTRAN (General Electric Co., Schenectady, NY) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 7 p. refs
(ASME PAPER 91-GT-73)

This paper summarizes the key properties of GTD-222, a new cast nickel-base nozzle alloy developed by GE for use in land-based gas turbines. GTD-222 is being introduced as a replacement for FSX-414 in second- and third-stage nozzles of certain machines. Presented in this paper are comparisons of the tensile, creep-rupture, and fatigue properties of GTD-222 versus FSX-414. In addition, the results of a long-term thermal stability study, high temperature oxidation and hot corrosion evaluation as well as weldability results are discussed. Author

A92-15567* *Norton Co., Northboro, MA.*
CERAMIC COMPONENT PROCESSING DEVELOPMENT FOR ADVANCED GAS-TURBINE ENGINES
B. J. MCENTIRE, R. R. HENGST, W. T. COLLINS, A. P. TAGLIALAVORE, R. L. YECKLEY, E. BRIGHT, and M. G. BINGHAM (Norton/TRW Ceramics, Northboro, MA) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 9 p. Research supported by NASA, DOE, Norton Co., et al. refs
(ASME PAPER 91-GT-120)

A review of ceramic component advancements directed at developing manufacturing technologies for rotors, stators, vane-seat platforms and scrolls is presented. The first three components are being produced from HIPed Si3N4, while scrolls were prepared from a series of siliconized silicon-carbide materials. Developmental work has been conducted on all aspects of the fabrication process utilizing Taguchi experimental design methods. An assessment of material properties for various components from each process and material are made. R.E.P.

A92-15590* Allied-Signal Aerospace Co., Torrance, CA.
DEVELOPMENT OF SILICON NITRIDE ROTORS FOR THE ATTAP PROGRAM AT GARRETT CERAMIC COMPONENTS
B. J. BUSOVNE, JR. and J. P. POLLINGER (Allied-Signal Aerospace Co., Garrett Ceramic Components Div., Torrance, CA) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. Research supported by DOE. refs
(Contract DEN3-335; DEN3-336)
(ASME PAPER 91-GT-154)

The development and fabrication of reliable high temperature-high strength silicon nitride rotors by Garrett Ceramic Components (GCC) for the Advanced Turbine Technology Applications Project (ATTAP) is discussed. GCC's progress will be presented, including mechanical properties characterization, in-process monitoring development, and extensive NDE analysis. The current status of material, process, and part properties of the rotors being developed will be compared to properties required for implementation and successful operation of advanced gas turbine engines at 2500 F. Author

A92-15592
DESIGN AND ANALYSIS OF CERAMIC AND CMC COMPONENTS FOR ADVANCED GAS TURBINES
K. D. KANNMACHER and L. E. GROSECLOSE (General Motors

Corp., Allison Gas Turbine Div., Indianapolis, IN) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 5 p. refs
(ASME PAPER 91-GT-156)

Both monolithic and composite structural ceramic components yield significant advantages over metallic superalloys in advanced gas turbine applications. The design methodology for monolithic ceramic components typically involves the use of Weibull probabilistic criteria; FEM-analysis modeling is used to ascertain component reliability. Additional design considerations are time-dependent behavior, ceramic/metal interfaces, and ceramic/ceramic interfaces. Ceramic-matrix composite design and analysis are intrinsically more complex due to material anisotropy, but allows advantageous tailoring of material architectures to accommodate specific component performance requirements. O.C.

A92-15632
HIGH TEMPERATURE EROSION RESISTANCE OF COATINGS FOR GAS TURBINE

W. TABAKOFF, A. HAMED, M. METWALLY, and M. PASIN (Cincinnati, University, OH) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 9 p. Research supported by DOE and Oak Ridge National Laboratory. refs
(ASME PAPER 91-GT-213)

An experimental investigation was conducted to study the ash particle rebound characteristics and the associated erosion behavior of superalloys and aluminide coatings subjected to gas-particle flows at elevated temperatures. A three-component LDV system was used to measure the restitution parameters of 15-micron-mean diameter coal ash particles impacting some widely used superalloys and coatings at different angles. The presented results show the variation of the particle restitution ratios with the impingement angle for the coated and uncoated superalloys. The erosion behaviors of INCO-738, MAR 246 and X40 superalloys and protective coatings C, N, RT22 and RT22B have also been investigated experimentally at high temperatures using a specially designed erosion tunnel. The erosion results show the effect of velocity, temperature and the impact angle on the erosion rate (weight loss per unit weight of particles). Based on the experimental results of the particle mass effect on both weight losses and erosion rates, the coating lives have been estimated for different particle concentrations. Author

A92-15702
CERAMIC MATRIX COMPOSITES AND ITS APPLICATION IN GAS TURBINE ENGINES

SUBHASH K. NAIK, ANDREW MASSAR (Textron Lycoming, Stratford, CT), JEAN F. LECOSTAOUEC, and BRUCE THOMSON (Textron Specialty Materials, Lowell, MA) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 7 p.
(ASME PAPER 91-GT-338)

An interturbine duct has been selected as the initial technology-demonstration component for a ceramic matrix composite of SiC fiber-reinforced Si3N4 composition, with a view to the development of a substantial material properties data base for both unidirectional and multidirectionally reinforced ceramic composites. It is shown that green ceramic composite preforms can be prepared from prepreg tapes; this yields excellent fiber/matrix distribution and enhances composite shape-forming capabilities. O.C.

A92-16583
LEAN LOW NO(X) COMBUSTION CONCEPT EVALUATION

N. K. RIZK and H. C. MONGIA (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) IN: Symposium (International) on Combustion, 23rd, Orleans, France, July 22-27, 1990, Proceedings. Pittsburgh, PA, Combustion Institute, 1991, p. 1063-1070. refs
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To investigate the potential of using the lean combustion concept to significantly reduce the emission of NO(x) from gas turbine combustors, a data analysis was conducted. The combustor tested comprises a prechamber in which the fuel is vaporized and mixed with air, pilot chamber, and main combustion chamber. A variable geometry feature is used to closely control the stoichiometry in the primary combustion zone to stay within the required operating limits. The combustor operating conditions used in the tests cover ranges of 1000 to 1200 K, and 0.004 to 0.01 for air inlet temperature and overall fuel/air ratio, respectively. The testing of the combustor showed that the NO(x) formation is sensitive to the variable-geometry position that determines the air flow split between the primary and dilution zones. An expression based on residence time and reaction rates in the combustion zones was derived to define the range of operation that gives acceptable NO(x) for future applications. The calculated overall NO(x) emissions, that combine the contributions from both the pilot and the main chambers agree well with the data. Author

A92-17188
ONE-DIMENSIONAL ANALYSIS OF LIQUID-FUELED COMBUSTION INSTABILITY

R. BHATIA and W. A. SIRIGNANO (California, University, Irvine) Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, Nov.-Dec. 1991, p. 953-961. Previously cited in issue 08, p. 1129, Accession no. A90-22192. refs
(Contract N00014-85-K-0658)
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N92-12060# Defence Research Establishment Pacific, Victoria (British Columbia). Research and Development Branch.
A DAMAGE TOLERANCE ASSESSMENT OF BONDED REPAIRS TO CF-18 COMPOSITE COMPONENTS. PART 1: ADHESIVE PROPERTIES

ALAN J. RUSSELL Dec. 1988 32 p
(DREP-TM-88-25-PT-1; AD-A210523; CTN-91-60270) Avail: NTIS HC/MF A03

The damage tolerance properties of three epoxy adhesives used in the manufacture and repair of the composite structure on the CF-18 aircraft are assessed. The resistance to both static fracture and fatigue crack growth are evaluated. Experimental variables include the mode of fracture (tension and shear), the fatigue load ratio, the test temperature and the method of bonding. Both the static and fatigue tests were found to rank the adhesives in the same order, viz. FM-300K superior to FM-300 superior to EA-9321. The fatigue testing revealed a tendency for delamination failures to occur at low temperature, a situation likely to lead to non conservative joint designs. The fatigue crack growth rate data are explained in terms of the failure mechanisms observed. The implication of these findings to the selection of repair adhesives for composite aircraft structure is discussed. Author (CISTI)

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ENGINEERING

Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

A92-13299
AN ANALYSIS METHOD AND APPLICATIONS FOR 3-D VISCOUS INTERNAL FLOWS WITH COMPLEX GEOMETRY

SHANGJIN WANG, GUANG XI, and YONGMIAO MIAO (Xian Jiaotong University, Xian, People's Republic of China) Journal of Engineering Thermophysics (ISSN 0253-231X), vol. 12, Aug. 1991, p. 274-278. In Chinese. refs

This paper develops an analysis method for 3D incompressible viscous flows, which uses the contravariant components on a

staggered grid as the dependent variables of the governing equations in general nonorthogonal curvilinear coordinates. Two calculation examples are carried out for 3D viscous flows in a centrifugal impeller and a bend duct to test the method developed. Author

A92-13432* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SLUSH HYDROGEN (SLH2) TECHNOLOGY DEVELOPMENT FOR APPLICATION TO THE NATIONAL AEROSPACE PLANE (NASP)
RICHARD L. DEWITT, TERRY L. HARDY, MARGARET V. WHALEN, and G. P. RICHTER (NASA, Lewis Research Center, Cleveland, OH) IN: Advances in cryogenic engineering. Vol. 35B - Proceedings of the 1989 Cryogenic Engineering Conference, Los Angeles, CA, July 24-28, 1989. New York, Plenum Press, 1990, p. 1741-1754. Previously announced in STAR as N90-14268. refs
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The National Aerospace Plane (NASP) program is giving us the opportunity to reach new unique answers in a number of engineering categories. The answers are considered enhancing technology or enabling technology. Airframe materials and densified propellants are examples of enabling technology. The National Aeronautics and Space Administration's Lewis Research Center has the task of providing the technology data which will be used as the basis to decide if slush hydrogen (SLH2) will be the fuel of choice for the NASP. The objectives of this NASA Lewis program are: (1) to provide, where possible, verified numerical models of fluid production, storage, transfer, and feed systems, and (2) to provide verified design criteria for other engineered aspects of SLH2 systems germane to an NASP. This program is a multiyear multimillion dollar effort. The present pursuit of the above listed objectives is multidimensional, covers a range of problem areas, works these to different levels of depth, and takes advantage of the resources available in private industry, academia, and the U.S. Government. The NASA Lewis overall program plan is summarized. The initial implementation of the plan will be unfolded and the present level of efforts in each of the resource areas will be discussed. Results already in hand will be pointed out. A description of additionally planned near-term experimental and analytical work is described. Author

A92-13554
LASER-BASED ULTRASONICS ON GR/EPOXY COMPOSITE - INTERFEROMETRIC DETECTION
B. R. TITTMANN, R. S. LINEBARGER, and R. C. ADDISON, JR. (Rockwell International Science Center, Thousand Oaks, CA) IN: Review of progress in quantitative nondestructive evaluation. Vol. 9A. New York, Plenum Press, 1990, p. 479-486. refs
(Contract W-7405-ENG-82)
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A92-13563
THE INFO-ROC TECHNIQUE - A METHOD FOR COMPARING AND OPTIMIZING INSPECTION SYSTEMS
EUGENE SOMOZA (USVA, Medical Center; Cincinnati, University, OH), DOUGLAS MOSSMAN, and LARRY MCFEETERS (Cincinnati, University, OH) IN: Review of progress in quantitative nondestructive evaluation. Vol. 9A. New York, Plenum Press, 1990, p. 601-608. refs
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This study shows how receiver operating characteristic (ROC) analysis describes the mathematical relationship between an inspection system and the relevant 'gold standards'. This combination of ROC analysis and information theory (INFO-ROC technique) is applied for demonstration purposes to a specific inspection system in which fluorescent penetrant dye is utilized to detect cracks in aircraft engine turbine blades. It is shown how INFO-ROC can be utilized to operationalize the inspection system for maximum efficiency, and how information theory can be employed to compare various inspection systems. R.E.P.

A92-13584
INSPECTION OF COMPRESSOR DISCS BY ULTRASONIC LEAKY WAVES USING AN AUTOMATED C-SCAN SYSTEM
A. FAHR, A. K. KOUL (National Aeronautical Establishment, Structures and Materials Laboratory, Ottawa, Canada), N. C. BELLINGER (Hawker Siddeley Canada, Inc., Orenda Div., Toronto), and P. STOUTE (Vac-Aero International, Inc., Oakville, Canada) IN: Review of progress in quantitative nondestructive evaluation. Vol. 9A. New York, Plenum Press, 1990, p. 941-950. refs
Copyright

The principles of the ultrasonic leaky wave technique and other procedures for inspecting compressor disks are described. A new leaky wave procedure using an automated C-scan is examined. Inspection results for the leaky wave method are compared with those using conventional liquid penetrant and eddy current techniques. C.D.

A92-13589
STATIONARY NEUTRON RADIOGRAPHY SYSTEM
DEAN B. HAGMANN (General Atomics, San Diego, CA) IN: Review of progress in quantitative nondestructive evaluation. Vol. 9A. New York, Plenum Press, 1990, p. 997-1004.
Copyright

The key components of a neutron-radiography inspection system are set forth in terms of the four major subsystems of the project in the light of the inspection of aircraft control surfaces. The paper describes the shielding and containment system (SCS), the Triga reactor system (TRS), the neutron beam system (NBS), and the component inspection system (CIS) which make up the Stationary Neutron Radiography System (SNRS). The TRS is a standard 1000-kW reactor, and the CIS is made up of subsystems for positioning and imaging the components as well as a digital image interpreter. Specific attention is given to the NBS in terms of imaging and interpretation subsystems. The SNRS is also described in terms of its construction and level of completion, and the system is prepared for reactor startup and subsequent operation. C.C.S.

A92-13594
EDDY CURRENT IMAGING OF AIRCRAFT USING REAL TIME IMAGE SIGNAL PROCESSING
M. W. KIRBY and J. P. LAREAU (Amdata, Inc., Windsor, CT) IN: Review of progress in quantitative nondestructive evaluation. Vol. 9A. New York, Plenum Press, 1990, p. 1055-1063. refs
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Real time signal processing requiring a minimum of computation time has been implemented in an eddy current C-scan imaging system. The system meets the design objectives of detecting subsurface corrosion corresponding to a 10-percent loss of wall and surface cracks of 0.06 inch in length. The signal processing system produces spatial displays of amplitude (in phase or quadrature), magnitude, and phase of spatial derivatives of these parameters. Results of laboratory and field tests are presented. V.L.

A92-13641
NONDESTRUCTIVE DEPTH PROFILING OF THE PROTECTIVE COATING ON A TURBINE BLADE
ANTHONY SINCLAIR, MICHAEL O'BRIEN, and VICTOR DASILVA (Toronto, University, Canada) IN: Review of progress in quantitative nondestructive evaluation. Vol. 9B. New York, Plenum Press, 1990, p. 1637-1643. Research supported by Pratt and Whitney Canada, Ontario University Research Incentive Fund, and NSERC. refs
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An ultrasonic method for measuring the thickness of the protective coating on turbine blades of turbo-prop engines was developed along with nondestructive methods for depth profiling of the aluminum and platinum contained in the coating. Calculations of the coating thickness using the equation relating the coating thickness with ultrasound measurements were found to agree to within about 20 percent of results from destructive analyses using

SEM. The major source of error is considered to be the speed of compression waves in coating materials. I.S.

A92-13657
THE AGING AIRCRAFT FLEET - A CHALLENGE FOR NONDESTRUCTIVE INSPECTION
STEPHEN N. BOBO (DOT, Transportation Systems Center, Cambridge, MA) IN: Review of progress in quantitative nondestructive evaluation. Vol. 9B. New York, Plenum Press, 1990, p. 2097-2109.
Copyright

The use of nondestructive inspection (NDI) is evaluated in terms of its applications to monitoring problems in aircraft such as crack-growth and corrosion detection and ascertaining the integrity of bonded lap joints. The Aging Aircraft Program NDI initiative includes an ongoing audit of heavy maintenance checks and a broad-based survey of NDI practice. NDI equipment types are evaluated, and criteria are developed for determining the effectiveness of inspection procedures. The relative advantages and disadvantages of using particular NDI methods are presented for visual-optical, penetrant, high-frequency eddy-current, sonic, X-ray, magnetic particle, and ultrasonic NDI techniques. NDI initiatives are also surveyed with attention given to potential technologies for evaluating the suitability of older aircraft for operation. C.C.S.

A92-14252
CLASSIFICATION OF RADAR CLUTTER USING NEURAL NETWORKS
SIMON HAYKIN and CONG DENG (McMaster University, Hamilton, Canada) IEEE Transactions on Neural Networks (ISSN 1045-9227), vol. 2, Nov. 1991, p. 589-600. Research supported by NSERC and Telecommunication Research Institute of Ontario. refs
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A classifier that incorporates both preprocessing and postprocessing procedures as well as a multilayer feedforward network (based on the back-propagation algorithm) in its design to distinguish between several major classes of radar returns including weather, birds, and aircraft is described. The classifier achieves an average classification accuracy of 89 percent on generalization for data collected during a single scan of the radar antenna. The procedures of feature selection for neural network training, the classifier design considerations, the learning algorithm development, the implementation, and the experimental results of the neural clutter classifier, which is simulated on a Warp systolic computer, are discussed. A comparative evaluation of the multilayer neural network with a traditional Bayes classifier is presented. I.E.

A92-14342
PROBABILISTIC FATIGUE METHODOLOGY FOR SIX NINES RELIABILITY
RICHARD A. EVERETT, JR., FELTON D. BARTLETT, JR., and WOLF ELBER (U.S. Army, Aerostructures Directorate, Hampton, VA) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 235-255. refs
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Current U.S. Army fatigue-life specifications for new rotorcraft stipulate a probability of failure of the order of 1 in 1 million, or 'six nines'. This criterion was arrived at through an examination of fatigue reliability under uniquely defined conditions for which only one answer was correct; other examinations covered the ways in which typical helicopter industry methods for the definition of fatigue strength affected mean fatigue life and reliability calculations. On the basis of the determinations thus arrived at, a probabilistic logic for the inclusion of both fatigue strength and spectrum-loading variability was established. O.C.

A92-14344
RELIABILITY OF HELICOPTER COMPOSITE DYNAMIC COMPONENTS
BOGDAN R. KRASNOWSKI and SATHY P. VISWANATHAN (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 273-284. refs
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An analytical methodology is formulated to evaluate the reliability of tension-loaded composite structures in the certification and design stages of product development. Use of full-scale fatigue test data in the certification stage and of coupon fatigue test data supported by energy release rate analysis in the design stage is recommended for development of the damage growth tree, which is the basis for reliability determination. Since the presence of a delamination can be detected by visual inspection, the proposed methodology considers both noninspectable and inspectable cases. A glass/epoxy main rotor yoke is used in an example problem to demonstrate the reliability analysis. The method used to determine the energy release rate, G for delaminations of a yoke loaded with centrifugal force and beamwise and chordwise bending moments is given. The energy release rate analysis of the yoke is used to present full-scale fatigue test data in terms of Gmax vs. N, which is then used to generate an S-N curve for subsequent delaminations of the yoke. Author

A92-14356
H-76B FANTAIL DEMONSTRATOR COMPOSITE FAN BLADE FABRICATION
THOMAS FALASCO, EDWARD ZACHAR, and ART LALLO (Boeing Defense and Space Group, Helicopters Div., Philadelphia, PA) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 399-405.
Copyright

A modified H-76B helicopter has been developed to demonstrate the performance and handling qualities of the LH Fantail antitorque system. Fantail blades are composed of graphite/fiberglass skins and spar, over a dual density foam core, with a leading-edge nickel erosion cap. The blade assembly is cured in a single bonding operation, with the exception of the nickel erosion cap and blade end closures which are secondarily bonded. Author

A92-14381
ENHANCED DIAGNOSTIC SYSTEM FOR AUTOCLAVES AND BONDING PRESSES
JIM BATES (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 749-753. refs
Copyright

A microcomputer based diagnostic system for thermoset cure processing autoclaves and bonding presses was developed and tested in a rotorcraft manufacturing facility. Various expert system methodologies were studied for this application. Embedded and stand-alone inference engines were tested as prototypes and reviewed by the users. Dedicated diagnostic expert system platforms were prototyped and analyzed. As a result of the development process, a relatively new form of programming known as hypermedia was tested and shown to be easier to implement, more acceptable to users and more economical than 'traditional' diagnostic expert systems. Hypermedia was used to blend graphics, scanned photographs, and text into an effective and easy to use diagnostic tool for engineers, operators and maintenance personnel responsible for the daily operation of computer controlled autoclaves and bonding presses. Author

A92-14441
DETERMINATION OF THE ENERGY ABSORPTION OF COMPOSITE STRUCTURES UNDER COMBINED LOADINGS
DAVID C. FLEMING and ANTHONY J. VIZZINI (Maryland, University, College Park) AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Paper. 8 p. refs

The phenomenon of energy absorption in truncated composite cones under side loads is investigated. Post mortem investigation

of experimental specimens shows changes in crushing mechanisms around the circumference which help explain changes in energy absorbency. Due to the complexity of the mixed-mode crushing event, calculated stress distributions do not indicate the observed changes in failure mechanisms. Calculated displacement data, however, do provide qualitative insights into the crushing phenomena. Author

A92-14449
PRODUCIBILITY DEMONSTRATOR PROGRAM - TECHNOLOGICAL PREEMINENCE THROUGH CONCURRENT ENGINEERING
ALEX C. DUBLINSKI (Sikorsky Aircraft, Stratford, CT) AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Paper. 6 p.

The design to costs targets for the next generation of composite aircraft require a significant reduction in fabrication costs. These types of aircraft bring with them additional complexity due to new technical requirements. To achieve these goals, Sikorsky Aircraft formed a multi-disciplined concurrent enginering team (CET). The primary objective of the team was to successfully produce a series of low cost, high quality composite components with a repeatable process. The program utilizes a 2D CAD system which allows the transfer of information to all organizations directly involved with the design effort. This system also provides a common data base. This paper highlights the results of the CET, which are: molded integrated structures using cocure processing technology, elastomeric caul/preply tooling, flexible trim and drill fixtures, and thermoplastic structures. Author

A92-14450
AUTOMATED COMPOSITE LAY-UP
ALLEN E. TRUDEAU (Sikorsky Aircraft, Stratford, CT) AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Paper. 3 p. refs

The development of an automated ply lay-up system is described emphasizing the robotics research and progress on the design of end effectors that make up the system. Also described are the systems for in-process ply forming and compaction and machine vision, and a typical graphite-composite fuselage bulkhead is used as the article for processing. The system for automated composite lay-up is found to effectively process woven prepreg plies into repeatable composite structures, and the time requirement is similar to that for manual operation. C.C.S.

A92-14556
A BASIS FOR ICE FORMATION DESIGN
R. S. LAFLEUR (Clarkson University, Potsdam, NY) IN: Computers in engineering 1990; Proceedings of the ASME International Computers in Engineering Conference and Exposition, Boston, MA, Aug. 5-9, 1990. Vol. 2. New York, American Society of Mechanical Engineers, 1990, p. 393-401. refs
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Previous ice formation investigations are reviewed, and the issues that need further investigation are indicated. A theoretical basis for optimization using the ice formation method is described, and two performance goals are formulated. The use of theory to select ice form thermal and flow control parameters leading to reduced drag juncture contour shapes is shown. C.D.

A92-14684
NUMERICAL MODELING TECHNIQUE FOR FIELD-TO-CABLE COUPLING THROUGH ADVANCED COMPOSITE MATERIAL
JUANG-LU LIN (Boeing Co., Military Airplanes Div., Seattle, WA) IN: IEEE 1990 International Symposium on Electromagnetic Compatibility, Washington, DC, Aug. 21-23, 1990, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 43-46. refs
Copyright

A numerical technique is presented for computing the short-circuit current of a cable inside of a finite hollow circular cylinder made of an advanced composite material, illuminated by an electromagnetic plane wave. The cylinder is modeled by wire-mesh techniques based on the method of moments and the electromagnetic fields inside the cylinder are found by means of surface transfer impedances of the material. Numerical examples compared with the measurements are also included. I.E.

A92-14689
COMPOSITE ELECTROMAGNETIC PULSE THREAT
ANDREW S. PODGORSKI (National Research Council of Canada, Div. of Electrical Engineering, Ottawa) IN: IEEE 1990 International Symposium on Electromagnetic Compatibility, Washington, DC, Aug. 21-23, 1990, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 224-227. refs
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A new electromagnetic pulse threat that is based on a composite ambient field defined by a combination of lightning, NEMP (nuclear electromagnetic pulse) and microwave threats is discussed. The composite electromagnetic pulse threat has been used to harden a military helicopter. The hardening to a composite threat resulted in the development of simplified hardening verification procedures. It also provided an economical advantage. I.E.

A92-15222
OPTIMIZATION OF THE FLUTTER LOAD BY MATERIAL ORIENTATION
OLE JORGENSEN (Technical University of Denmark, Lyngby) Mechanics of Structures and Machines (ISSN 0890-5452), vol. 19, Sept. 1991, p. 411-436. refs
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The present work concerns optimization of the stability of composite plates for supersonic flutter. A finite element model of the structure is applied. The individual material orientation within each finite element defines the degrees of freedom in the design space. Design iterations are based on analytical sensitivity analyses, derived by Pedersen and Seyranian. Plaut's flutter instability condition is discussed. The condition implies the possibility of an accurate flutter analysis without reducing the eigenvalue problem. For one particular choice of material, an optimal design, in the case of a rectangular, simply supported plate, is found. Design iterations on a delta-shaped plate supported as a cantilever are discussed. A condition for when static divergence is not a possible consequence of the aerodynamic load for any design is derived. Author

A92-15343
AEROELASTIC TAILORING OF AERONAUTICAL COMPOSITE WING STRUCTURES
CHUANQI HUANG and XIN QIAO (Nanjing Aeronautical Institute, People's Republic of China) Chinese Journal of Aeronautics (ISSN 1000-9361), vol. 4, May 1991, p. 245-256. Research supported by Chinese Academy of Sciences and National Education Committee. refs
Copyright

This paper deals with the aeroelastic tailoring of aeronautical composite wing surfaces. The objective function is structural weight. Multi-constraints such as displacements, flutter speed and gauge requirements, are taken into consideration. Finite element method is used to the static analysis. Natural vibration modes are obtained by the spectral transformation Lanczos method. Subsonic doublet lattice method is used to obtain the unsteady aerodynamics. The critical flutter speed is generated by V-g method. The optimal problem is solved by the feasible direction method. The thickness of the composite wing skin is simulated by bicubic polynomials, whose coefficients combined with the cross-sectional areas or thicknesses of other finite elements are the design variables. The scale of the problem is reduced by variable linkage. Derivative analysis is performed analytically. Two composite wing boxes and a swept-back composite wing are optimized at the end of the paper. Author

A92-15358
OSCILLATION OF NEARLY CIRCULAR SHOCK WAVES
MYEONG-KWAN PARK, SHUZO OSHIMA, and RYUICHIRO YAMANE (Tokyo Institute of Technology, Japan) JSME

International Journal, Series II (ISSN 0914-8817), vol. 34, Nov. 1991, p. 447-456. refs
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Oscillation modes of nearly circular shock waves in supersonic radial flow were investigated both theoretically and experimentally. The shock waves deformed from circular shape were obtained by the asymmetric back pressure produced by downstream obstacles. Oscillation modes of the shock waves were investigated by means of statical study of the phase function and mean coherence in each static mode. The oscillation consisted of mode 0 and the same mode as the original static shape. The frequency of each static mode depended on the deformation from the real circle. Author

A92-15501
AN AXIAL TURBOBRAKE
M. I. GOODISMAN, M. L. G. OLDFIELD, T. V. JONES, R. W. AINSWORTH (Oxford, University, England), R. C. KINGCOMBE, and A. J. BROOKS (Royal Aerospace Establishment, Farnborough, England) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. Research supported by Royal Aerospace Establishment. refs
(ASME PAPER 91-GT-1)

The Axial Turbobrake is a novel turbomachine which can be used to absorb power generated by test turbines. Unlike a compressor, there is no pressure recovery through the turbobrake. This simplifies the aerodynamic design and enables high-stage loadings to be achieved. The blades used have high-turning 2D profiles. This paper describes a single stage axial turbobrake, which is driven by the exhaust gas of the test turbine and is isolated from the turbine by a choked throat. In this configuration, no fast-acting controls are necessary, as the turbobrake operates automatically with the turbine flow. Tests on a 0.17 scale model show that the performance is close to that predicted by a simple two-dimensional theory, and demonstrate that the turbobrake power absorption can be controlled, and hence matched, to that typically produced by the first stage of a modern highly loaded transonic turbine. Author

A92-15510* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
OPTICAL MEASUREMENTS OF UNDUCTED FAN FLUTTER
ANATOLE P. KURKOV and ORAL MEHMED (NASA, Lewis Research Center, Cleveland, OH) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 9 p. Previously announced in STAR as N91-15174. refs
(ASME PAPER 91-GT-19)

A nonintrusive optical method is described for flutter vibrations in unducted fan or propeller rotors and provides detailed spectral results for two flutter modes of a scaled unducted fan. The measurements were obtained in a high-speed wind tunnel. A single-rotor and a dual-rotor counterrotating configuration of the model were tested; however, only the forward rotor of the counterrotating configuration fluttered. Conventional strain gages were used to obtain flutter frequency; optical data provided complete phase results and an indication of the flutter mode shape through the ratio of the leading- to trailing-edge flutter amplitudes near the blade tip. The transonic regime exhibited some features that are usually associated with nonlinear vibrations. Experimental mode shape and frequencies were compared with calculated values that included centrifugal effects. Author

A92-15516
PERFORMANCE OF RADIAL CLEARANCE RIM SEALS IN UPSTREAM AND DOWNSTREAM ROTOR-STATOR WHEELSPACES
S. DADKHAN, A. B. TURNER, and J. W. CHEW (Sussex, University, Brighton, England) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. Research supported by Rolls-Royce, PLC. refs
(ASME PAPER 91-GT-32)

A new experimental facility for the investigation of rim sealing is described, and measurements are presented for two representative radial clearance seals with a nominally axisymmetric external flow. One radial seal has an upward rotor lip and is upstream of the rotor while the other has an upward stator lip and is downstream of the rotor. Measurements include surface pressures, tangential velocities in the core region of the disk cavity flow, and traverses of gas concentration in the cavity showing the distribution of mainstream ingestion. Tests were conducted at rotational Reynolds numbers up to 3 x 10 exp 6 with nominal seal clearance to radius ratios in the range 0.002 to 0.01. For the radial seals, a differential pressure criterion is found to overestimate the minimum sealing flow. Tangential velocity measurements in the wheelspace are in excellent agreement with other measurements and theoretical predictions. Author

A92-15517
RIM SEALING OF ROTOR-STATOR WHEELSPACES IN THE ABSENCE OF EXTERNAL FLOW
J. W. CHEW, S. DADKHAN, and A. B. TURNER (Sussex, University, Brighton, England) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 7 p. Research supported by Rolls-Royce, PLC, Ruston Gas Turbines, Ltd., and SERC. refs
(ASME PAPER 91-GT-33)

Sealing of the cavity formed between a rotating disk and a satator in the absence of a forced external flow is considered. In these circumstances, the pumping action of the rotating disk may draw fluid into the cavity through the rim seal. Minimum cavity throughflow rates required to prevent such ingress are estimated experimentally and from a mathematical model. Measurements for three different types of rim are reported for a range of seal clearance and for rotational Reynolds numbers up to 3 x 10 exp 6. The mathematical model is found to correlate the experimental data reasonably well. Author

A92-15518
CONVECTIVE TRANSPORT PHENOMENA ON THE SUCTION SURFACE OF A TURBINE BLADE INCLUDING THE INFLUENCE OF SECONDARY FLOWS NEAR THE ENDWALL
P. H. CHEN and R. J. GOLDSTEIN (Minnesota, University, Minneapolis) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 13 p. Research supported by USAF. refs
(ASME PAPER 91-GT-35)

A naphthalene sublimation technique is employed to study the mass transfer distribution on the suction (convex) surface of a simulated turbine blade. Comparison with a heat transfer study shows good agreement in the general trends in the region of two-dimensional flow on the blade. Near the endwall, local convective coefficients on the suction surface are obtained at 4608 locations from two separate runs. The secondary flows in the passage significantly affect the mass transfer rate on the suction surface and their influence extends to a height of 75 percent of the chord length, from the endwall, in the trailing edge region. The mass transfer rate in the region near the endwall is extremely high due to small but intense vortices. Thus, a large variation in the mass transfer distribution occurs on the suction surface, from a mass tranfer Stanton number of 0.0005 to a maximum of 0.01. In the two-dimensional flow region, the mass transfer distributions at two different Reynolds number are presented. Author

A92-15523* Pratt and Whitney Aircraft Group, East Hartford, CT.
THERMAL BARRIER COATING LIFE PREDICTION MODEL DEVELOPMENT
SUSAN M. MEIER, DAVID M. NISSLEY, KEITH D. SHEFFLER (Pratt and Whitney Group, East Hartford, CT), and THOMAS A. CRUSE (Vanderbilt University, Nashville, TN) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 7 p. refs
(Contract NAS3-23944)
(ASME PAPER 91-GT-40)

A thermal barrier coated (TBC) turbine component design

system, including an accurate TBC life prediction model, is needed to realize the full potential of available TBC engine performance and/or durability benefits. The objective of this work, which was sponsored in part by NASA, was to generate a life prediction model for electron beam - physical vapor deposited (EB-PVD) zirconia TBC. Specific results include EB-PVD zirconia mechanical and physical properties, coating adherence strength measurements, interfacial oxide growth characteristics, quantitative cyclic thermal spallation life data, and a spallation life model. Author

A92-15528
DYNAMIC ANALYSIS TECHNIQUE OF ROTATING CENTRIFUGAL IMPELLER
JIN ZHANG (Beijing University of Aeronautics and Astronautics, People's Republic of China), X. J. CHEN (Wuxi Aero-engine Design Research Institute, People's Republic of China), and W. L. WANG (Fudan University, Shanghai, People's Republic of China) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 5 p. refs
(ASME PAPER 91-GT-50)

A dynamic analysis technique which can be employed in a rotating centrifugal impeller is presented. It shows that multicomponent partition can be made in repetitive sector region of the centrifugal impeller. The basic repetitive sector region of the centrifugal impeller is divided into three substructures: the full blade, the short blade and the sectorial part of the disk. By using Benfield mode substitution combined with group transformation successfully, the Hermite generalized mass and stiffness matrices under the reduced coordinates are derived. From this, the natural frequencies and the corresponding modal shapes of the bladed disk coupled system can be solved. The comparison of the analytical results obtained by using this method, other methods and the experimental data of models verifies the reliability, practicability and considerable economic benefits of the method presented. Author

A92-15540
OPTIMIZING INSTRUMENTATION WHEN MEASURING JET ENGINE BLADE VIBRATION
J. H. GRIFFIN (Carnegie Mellon University, Pittsburgh, PA) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 7 p. refs
(Contract F33615-84-C-2454)
(ASME PAPER 91-GT-71)

An analytical model of bladed disk vibration is used to calculate the statistical variations in blade amplitudes that can occur in mistuned turbomachinery blading. The results provide a basis for evaluating alternative strategies for instrumenting the stage. This approach is illustrated by applying it to an unshrouded fan stage. It is found for this stage that the best strategy is to instrument blades that have frequencies near the tuned system frequency. A procedure is proposed for establishing how gages should be allocated from stage to stage throughout the engine. Author

A92-15587
EXPERIMENTS ON THE BLADE LOSS TRANSIENT RESPONSE OF ROTOR WITH FLEXIBLE DAMPED SUPPORT
QIHAN LI, SHIPING ZHANG, LITANG YAN, and FUAN ZHAO (Beijing University of Aeronautics and Astronautics, People's Republic of China) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 6 p. refs
(ASME PAPER 91-GT-149)

The purpose of this paper is to present some experimental results on the transient response dynamics of a rotor system with flexible damped support due to the event of simulated blade loss. Experiments under different sudden unbalances applied on the rotor system with various SFD film clearances at different rotational speeds were performed. The instability conditions characterized by limiting circle orbits for large amplitude at damper location were determined and some special phenomena such as lock up, bistable jump and subharmonic, etc., have been observed. The effectiveness and the capability of SFD for suppressing instability are analyzed. Author

A92-15588
FATIGUE DUE TO NOISE-INDUCED PRESSURE
T. W. WU, A. F. SEYBERT (Kentucky, University, Lexington), and J. J. WANG (Terra Tek, Inc., Salt Lake City, UT) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 5 p. refs
(ASME PAPER 91-GT-150)

The paper presents results of a preliminary study of the acoustic fatigue of an airframe structure as a result of turbojet engine noise. The acoustic pressure distribution, induced by jet-noise, is determined by a coupled FEM/BEM approach. A model of an airframe structure with no defects or microcracks is assumed to be subjected to loadings induced by a time-harmonic noise source. Solution techniques are summarized. A method is presented to analyze the acoustic stresses, additional to mechanical loading induced stresses, for the potential to initiate fatigue cracks and propagation of these cracks. Applications to similar structural systems are suggested. Author

A92-15593* Texas A&M Univ., College Station.
AERODYNAMICS AND HEAT TRANSFER INVESTIGATIONS ON A HIGH REYNOLDS NUMBER TURBINE CASCADE
TAHER SCHOBEIRI (Texas A & M University, College Station), ERIC MCFARLAND, and FREDERICK YEH (NASA, Lewis Research Center, Cleveland, OH) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 11 p. Previously announced in STAR as N91-15134. refs
(ASME PAPER 91-GT-157)

The results of aerodynamic and heat transfer experimental investigations performed in a high Reynolds number turbine cascade test facility are analyzed. The experimental facility simulates the high Reynolds number flow conditions similar to those encountered in the Space Shuttle Main Engine. In order to determine the influence of Reynolds number on aerodynamic and thermal behavior of the blades, heat transfer coefficients were measured at various Reynolds numbers using liquid crystal temperature measurement technique. Potential flow calculation methods were used to predict the cascade pressure distributions. Boundary layer and heat transfer calculation methods were used with these pressure distributions to verify the experimental results. Author

A92-15594
GAS-GENERATOR WITH HIGH-TEMPERATURE PATH CERAMIC COMPONENTS
A. V. SUDAREV, V. H. DUBERSHTEIN, V. P. KOVALEVSKII, and A. E. GINZBURG (Vsesoiuznyi Nauchno-Issledovatel'skii Tekhnologicheskii Institut Energeticheskogo Mashinostroeniia, Leningrad, USSR) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 9 p. refs
(ASME PAPER 91-GT-152)

The paper presents a theoretical design study of ceramic components of gas turbine units (GTUs) for a multishaft gas generator. An investigation of the efficiency and application of various materials for ceramic turbine wheels was conducted, including an analysis of thermal and stress state of rotor ceramic components. As a result, the design of various components, including turbine rotor, was improved. I.S.

A92-15614
***5,000-HOUR STABILITY TESTS OF* METAL SHEATHED THERMOCOUPLES AT RESPECTIVE TEMPERATURES OF 538 C AND 875 C**
T. P. WANG, A. WELLS, and D. BEDIONES (Thermo Electric, Saddle Brook, NJ) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 7 p. refs
(ASME PAPER 91-GT-182)

Metal-sheathed mineral-insulated thermocouples used for the

measurement of exhaust-gas temperatures in turbines and aircraft engines are usually not replaced after initial installation. Therefore, the change in calibration of the thermocouples during service is of interest. In this paper, two 5000-hour stability tests were conducted on standard and nonstandard thermocouples in the laboratory in air atmosphere at 538 C, the midtemperature for gas turbine application and at 875 C, near the high end of aircraft engine applications. A comparison is made on calibration changes between the laboratory and the actual environment. Future work involving the extension of the 875 C beyond 5000 hours, laboratory testing in reducing atmospheres, and in situ testing are proposed. Author

A92-15617
DEVELOPMENT AND CHARACTERIZATION OF HIGH STRENGTH SIC ROTORS
R. W. OHNSORG and G. V. SRINIVASAN (Carborundum Co., Technology Div., Niagara Falls, NY) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 9 p. Research sponsored by DOE. refs
(ASME PAPER 91-GT-191)

Sintered alpha-SiC (Hexoloy SA) turbine engine components have been fabricated by Carborundum for the Advanced Gas Turbine (AGT) Program and, more recently, for the Advanced Turbine Technology Applications Project (ATTAP) using three primary forming procedures - injection molding, cold isostatic pressing (CIP) followed by green machining, and slip casting. The near net-shape fabrication of injection molded AGT-100 radial rotors for the Allison Gas Turbine Division (AGTD) of General Motors Corporation and, more recently, AGT-5 axial rotors, has been demonstrated. The current emphasis at Carborundum is to refine the injection molding process, bringing it to a performance and reproducibility level sufficient for production needs. The process changes leading to increases in component strength from approximately 380 MPa (55 ksi) to 595 MPa (86 ksi) will be discussed, as well as investigation of the failure mechanism and proposed process modifications to enhance properties even further. Author

A92-15624
COMBINATION OF DIFFERENT UNSTEADY QUANTITY MEASUREMENTS FOR GAS TURBINE BLADE FAULT DIAGNOSIS
E. LOUKIS, P. WETTA, K. MATHIOUDAKIS, A. PAPATHANASIOU, and K. PAPAILIOU (Athens, National Technical University, Greece) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. Research supported by Hellenic General Secretariat for Research and Technology and EEC. refs
(ASME PAPER 91-GT-201)

The exploitation of different unsteady quantity measurements for identifying various blade faults is examined in this paper. Measurements of sound emission, casing vibration, shaft displacement and unsteady inner wall pressure are considered. It is demonstrated that particular measurements are sensitive to specific faults. The suitability of measuring each of the above physical quantities for tracing the existence of each kind of fault is discussed. The advantage of combining different measurements originates from the possibility of extending the fault repertory covered when only one particular quantity is considered. The data analysis techniques employed range from conventional signal processing to the derivation of acoustic images of the engine outer surface. Relative features of each technique, as to their effectiveness and level of intrusivity, are discussed. Author

A92-15641
PRECISION DRILLING OF CERAMIC-COATED COMPONENTS WITH ABRASIVE-WATERJETS
M. HASHISH (Quest Integrated, Inc., Kent, WA) and J. WHALEN (GE Aircraft Engines, Cincinnati, OH) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 6 p. refs
(Contract F33657-83-C-0281)
(ASME PAPER 91-GT-232)

This paper addresses an experimental investigation on the feasibility of using abrasive-waterjets (AWJs) for the precision drilling of small-diameter holes in advanced aircraft engine components. These components are sprayed with ceramic thermal barrier coating (TBC), and the required holes are typically 0.025 inch in diameter with a drilling angle of 25 deg. The parameters of the AWJ were varied to study their effects on both quantitative and qualitative hole drilling parameters. The unique techniques of assisting the abrasive feed process, ramping the waterjet pressure during drilling, and varying the jet dwell time after piercing were effectively implemented to control hole quality and size. The results of the experiments indicate the accuracy and repeatability of the AWJ technique in meeting the air flow and hole size requirements. Production parts were drilled for prototype engine testing. Author

A92-15647
ROTORDYNAMIC EVALUATION OF AN ADVANCED MULTI-SQUEEZE FILM DAMPER - IMBALANCE RESPONSE AND BLADELOSS SIMULATION
J. F. WALTON, II and H. HESHMAT (Mechanical Technology, Inc., Latham, NY) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 7 p. refs
(Contract F33615-85-C-2518)
(ASME PAPER 91-GT-242)

Results of rotordynamic response and transient tests of a high-load squeeze film-damper design are presented. The spiral-foil multisqueeze film damper has been previously shown to provide two- to fourfold or larger increases in damping levels without resorting to significantly decreased damper clearances or increased lengths. By operating with a total clearance of approximately twice conventional designs, the nonlinearities associated with high-eccentricity operation are avoided. Rotordynamic tests with a dual squeeze film configuration were completed. As a part of the overall testing program, a flexible rotor system was subjected to high steady-state imbalance levels and transient simulated bladeloss events for up to 0.01 in mass c.g offset of 2.5 oz-in imbalance. The spiral foil multi-squeeze film damper demonstrated that the steady-state imbalance and simulated bladeloss transient response of a flexible rotor operating above its first bending critical speed could be readily controlled. Rotor-system imbalance sensitivity and logarithmic decrement are presented showing the characteristics of the system with the damper installed. The ability to accommodate high steady-state and transient imbalance conditions make this damper well suited to a wide range of rotating machinery, including aircraft gas turbine engines. Author

A92-15648
A CHAMBERED POROUS DAMPER FOR ROTOR VIBRATION CONTROL. II - IMBALANCE RESPONSE AND BLADELOSS SIMULATION
J. WALTON and M. MARTIN (Mechanical Technology, Inc., Latham, NY) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 7 p. refs
(Contract F33615-85-C-2518)
(ASME PAPER 91-GT-243)

In this paper, results of experimental rotordynamic evaluations of a novel, high load chambered porous damper design, are presented. The chambered porous damper concept was evaluated for gas turbine engine application since this concept avoids the nonlinearities associated with high eccentricity operation of conventional squeeze film dampers. The rotordynamic testing was conducted under large steady state imbalance and simulated transient bladeloss conditions for up to 0.254 mm (0.01 in) mass c.g offset or 180 gm-cm (2.5 oz-in) imbalance. The chambered porous damper demonstrated that the steady state imbalance and simulated bladeloss transient response of a flexible rotor operating above its first bending critical speed could be readily controlled. Rotor system imbalance sensitivity and logarithmic decrement are presented showing the characteristics of the system with the

damper installed. The ability to accommodate high steady state and transient imbalance conditions make this damper well suited to a wide range of rotating machinery, including aircraft gas turbine engines. Author

A92-15649
A CHAMBERED POROUS DAMPER FOR ROTOR VIBRATION CONTROL. I - CONCEPT DEVELOPMENT
J. TECZA and J. WALTON (Mechanical Technology, Inc., Latham, NY) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 7 p. refs
(Contract F33615-85-C-2518)
(ASME PAPER 91-GT-244)

In this paper a novel, high load chambered porous damper design, supporting analysis, and experimental results are presented. It was demonstrated that significant damping can be generated from the viscous discharge losses of capillary tubes arranged in chambered segments with large radial clearances and that the resulting damping is predictable and fairly constant with speed and eccentricity ratio. This design avoids the nonlinearities associated with high eccentricity operation of conventional squeeze film dampers. Controlled orbit tests with a porous chambered configuration were completed and favorably compared with theoretical predictions. The ability to accommodate high steady state and transient imbalance conditions make this damper well suited to a wide range of rotating machinery, including aircraft gas turbine engines. Author

A92-15653
THE BASICS OF POWDER LUBRICATION IN HIGH-TEMPERATURE POWDER-LUBRICATED DAMPERS
HOOSHANG HESHMAT and JAMES F. WALTON (Mechanical Technology, Inc., Latham, NY) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 12 p. refs
(ASME PAPER 91-GT-248)

A powder-lubricated rotor bearing system damper concept is developed for use in high-temperature, high-speed rotating machinery such as advanced aircraft gas turbine engines. The approach consists of replacing a conventional oil lubrication or frictional damper system with a powder lubrication system that uses the process particulates or externally-fed powder lubricant. This approach is based on the postulate of the quasi-hydrodynamic nature of powder lubrication. This postulate is deduced from past observation and present verification that there are a number of basic features of powder flow in narrow interfaces that have the characteristic behavior of fluid-film lubrication. In addition to corroborating the basic mechanism of powder lubrication, the conceptual and experimental work performed in this program provides guidelines for selection of the proper geometries, materials and powders suitable for this tribological process. Author

A92-15654
A GAS OPERATED BEARING DAMPER FOR TURBOMACHINERY
JOHN M. VANCE, BRADLEY P. CARDON, LUIS A. SAN ANDRES (Texas A & M University, College Station), and ALBERT F. STORACE (GE Aircraft Engines, Cincinnati, OH) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 11 p. refs
(ASME PAPER 91-GT-249)

A gas-operated bearing damper for turbomachinery is designed, analyzed, and experimentally investigated in the laboratory. The damper utilizes air bled off from the compressor to power an actuator through orifices with area modulated by the vibratory displacement at the bearing support. The design objective for this passive device is to make the actuating dynamic-gas-pressure phase lead the vibratory displacement by 90 degrees. All of the designs tested to date can produce positive damping, and one particular design produces a damping coefficient of 8756 N-s/m with a power penalty of 5.2 kW at 310 KPa (45 psi). This design was installed on a laboratory rotor with flexibly supported ball bearings, and significant damping of the criticl speed response was demonstrated. The device appears to be especially adaptable to high-temperature applications for aircraft engines. Author

A92-15655
EXPERIMENTAL AND ANALYTICAL INVESTIGATION OF HYBRID SQUEEZE FILM DAMPERS
A. EL-SHAFEL (Cairo University, Giza, Egypt) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 7 p. Research supported by University of South Florida. refs
(ASME PAPER 91-GT-250)

A new concept for actively controlling high speed rotating machinery is investigated both analytically and experimentally. The controlling mechanism consists of a hybrid squeeze film damper that can be adaptively controlled to change its characteristics according to the instructions of a controller. In an extreme case the hybrid damper can act as a long damper which is shown to be effective in reducing the amplitude of vibration of rotating machinery. In the other extreme the hybrid damper acts as a short damper which is shown to be effective in reducing the force transmitted to the support. In the long damper configuration the oil flow is circumferential, while in the short damper configuration the oil flow is predominantly axial. The hybrid damper is designed to operate in either of the short or the long damper configurations by controlling the positions of two movable sealing rings. The hybrid damper was tested on a Bently Nevada Rotor Kit and it is shown experimentally that the long damper configuration is extremely efficient at controlling the amplitude of vibration and the short damper configuration reduces the force transmitted to the support. Author

A92-15657
FILM COOLING RESEARCH ON THE ENDWALL OF A TURBINE NOZZLE GUIDE VANE IN A SHORT DURATION ANNULAR CASCADE. I - EXPERIMENTAL TECHNIQUE AND RESULTS
S. P. HARASGAMA and C. D. BURTON (Royal Aerospace Establishment, Propulsion Dept., Farnborough, England) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. refs
(ASME PAPER 91-GT-252)

Heat transfer and aerodynamic measurements have been made on the endwalls of an annular cascade of turbine nozzle guide vanes in the presence of film cooling. The results indicate that high levels of cooling effectiveness can be achieved on the endwalls of turbine nozzle guide vanes (NGV). The NGV were operated at the correct engine nondimensional conditions of Reynolds number, Mach number, gas-to-wall temperature ratio and gas-to-coolant density ratio. Author

A92-15658
FILM COOLING RESEARCH ON THE ENDWALL OF A TURBINE NOZZLE GUIDE VANE IN A SHORT DURATION ANNULAR CASCADE. II - ANALYSIS AND CORRELATION OF RESULTS
S. P. HARASGAMA and C. D. BURTON (Royal Aerospace Establishment, Propulsion Dept., Farnborough, England) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 7 p. refs
(ASME PAPER 91-GT-253)

Measurements of the heat transfer characteristics of the film cooled endwall (platform) of a turbine nozzle guide vane in an annular cascade at engine representative conditions are analyzed. The experimental results are well represented by the superposition theory of film cooling. It is shown that high cooling effectiveness can be achieved when the data are corrected for axial pressure gradients. The data are correlated against both the slot-wall jet parameter and the discrete hole injection function for flat-plate, zero pressure gradient cases. The pressure gradient correction brings the data to within +/- 11 percent of the discrete hole correlation. Author

A92-15660
THE INFLUENCE OF DENSITY DIFFERENCE BETWEEN HOT AND COOLANT GAS ON FILM COOLING BY A ROW OF HOLES - PREDICTIONS AND EXPERIMENTS
W. HAAS, W. RODI, and B. SCHOENUNG (Karlsruhe, Universitaet, Federal Republic of Germany) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 10 p. Research sponsored by Forschungsvereinigung Verbrennungskraftmaschinen. refs
(ASME PAPER 91-GT-255)

The 2D boundary layer procedure of Schoenung and Rodi (1987) for calculating film cooling by a row of holes is extended to account for the effect of the density difference between the hot gas and the injected coolant gas. The extended film cooling model covers the full range of the parameters, including the injection angle, relative spacing, blowing rate, and density ratio of practical interest. The model has been tested against flat-plate experiments and experiments on a model turbine blade. In general, the model provides a good prediction of the effect of the density difference. V.L.

A92-15661
A PROCEDURE FOR AUTOMATED GAS TURBINE BLADE FAULT IDENTIFICATION BASED ON SPECTRAL PATTERN ANALYSIS
E. LOUKIS, K. MATHIOUDAKIS, and K. PAPAILIOU (Athens, National Technical University, Greece) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 9 p. refs
(ASME PAPER 91-GT-259)

A method for diagnosing the existence and the kind of faults in blades of a gas turbine compressor is presented. The innovative feature of this method is that it performs the diagnosis automatically, namely it gives a direct answer to whether a fault exists and what fault it is, without requiring the interpretation of results by a human expert. This is achieved by the derivation of the values of discriminants calculated from spectral patterns of fast response measurement data. A decision about the corresponding engine status is then derived according to the values of these discriminants. Author

A92-15663* United Technologies Research Center, East Hartford, CT.
HEAT TRANSFER IN ROTATING SERPENTINE PASSAGES WITH TRIPS NORMAL TO THE FLOW
J. H. WAGNER, B. V. JOHNSON (United Technologies Research Center, East Hartford, CT), R. A. GRAZIANI (Pratt and Whitney Group, East Hartford, CT), and F. C. YEH (NASA, Lewis Research Center, Cleveland, OH) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 13 p. Research supported by United Technology Corp. Previously announced in STAR as N91-19443. refs
(Contract NAS3-23691)
(ASME PAPER 91-GT-265)

Experiments were conducted to determine the effects of buoyancy and Coriolis forces on heat transfer in turbine blade internal coolant passages. The experiments were conducted with a large scale, multipass, heat transfer model with both radially inward and outward flow. Trip strips on the leading and trailing surfaces of the radial coolant passages were used to produce the rough walls. An analysis of the governing flow equations showed that four parameters influence the heat transfer in rotating passages: coolant-to-wall temperature ratio, Rossby number, Reynolds number, and radius-to-passage hydraulic diameter ratio. The first three of these four parameters were varied over ranges which are typical of advanced gas turbine engine operating conditions. Results were correlated and compared to previous results from stationary and rotating similar models with trip strips. The heat transfer coefficients on surfaces, where the heat increased with rotation and buoyancy, varied by as much as a factor of four. Maximum values of the heat transfer coefficients with high rotation were only slightly above the highest levels obtained with the smooth wall model. The heat transfer coefficients on surfaces, where the heat transfer decreased with rotation, varied by as much as a factor of three due to rotation and buoyancy. It was concluded that both Coriolis and buoyancy effects must be considered in turbine blade cooling designs with trip strips and that the effects of rotation were markedly different depending upon the flow direction. Author

A92-15666
COMPARISON OF TIME-RESOLVED TURBINE ROTOR BLADE HEAT TRANSFER MEASUREMENTS AND NUMERICAL CALCULATIONS
R. S. ABHARI, G. R. GUENETTE, A. H. EPSTEIN, and M. B. GILES (MIT, Cambridge, MA) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 10 p. Research supported by Rolls-Royce, Inc. refs
(ASME PAPER 91-GT-268)

Time-resolved rotor blade heat transfer measurements, performed on a transonic uncooled single-stage turbine in a short duration turbine test facility, are compared with numerical calculations at two operating points. In both cases, the 2D unsteady multiblade row code predicts about 90 percent of the measured integrated heat load to the blades. Some differences between the calculation results and the measurements are examined in order to assess the impact of various modeling assumptions and numerical approximations. V.L.

A92-15667
DISCHARGE COEFFICIENTS OF COOLING HOLES WITH RADIUSED AND CHAMFERED INLETS
N. HAY and A. SPENCER (Nottingham, University, England) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 7 p. refs
(ASME PAPER 91-GT-269)

The flow of cooling air within the internal passages of gas turbines is controlled and metered using holes in disks and casings. The effects of inlet radiusing and chamfering of these holes on the discharge coefficient are discussed. Experimental results for a range of radiusing and chamfering ratios for holes of different length to diameter ratios are presented, covering the range of pressure ratios of practical interest. The results indicate that radiusing and chamfering are both beneficial in increasing the discharge coefficient. Increases of 10-30 percent are possible. Chamfered holes give the more desirable performance characteristics in addition to being easier to produce than radiused holes. Author

A92-15668
VALIDATION OF A NUMERICAL METHOD FOR UNSTEADY FLOW CALCULATIONS
MICHAEL GILES and ROBERT HAIMES (MIT, Cambridge, MA) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 9 p. Research supported by Rolls-Royce, PLC. refs
(ASME PAPER 91-GT-271)

This paper describes and validates a numerical method for the calculation of unsteady inviscid and viscous flows. The mathematical model is the Reynolds-averaged unsteady Navier-Stokes equations for a compressible ideal gas. Quasi-three-dimensionality is included through the use of a variable streamtube thickness. Several test cases are presented to validate the performance of the computer program. These include: unsteady, inviscid flat plate cascade flows; steady and unsteady, viscous flat plate cascade flows; and steady turbine heat transfer and loss prediction. Author

A92-15672
THERMAL DETAILS IN A ROTOR-STATOR CAVITY AT ENGINE CONDITIONS WITH A MAINSTREAM
S. H. KO and D. L. RHODE (Texas A & M University, College Station) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 10 p. Research supported by Texas A & M Turbomachinery Research

Consortium. refs
(ASME PAPER 91-GT-275)

This investigation involves a numerical study of enclosed rotor-stator cavities of gas turbine engines. The complete elliptic form of the 2D, axisymmetric Navier-Stokes equations for compressible turbulent flow were solved. Included are the complete fluid and thermal effects of the hot mainstream gas interacting with the cooling cavity purge flow at actual engine flow conditions for generalized geometries. Additional flow conditions above and below that for engine nominal conditions are also considered. The relationships among the important flow parameters are investigated by examining the entire set of computations. The predictions reveal that a small recirculation zone in the stator shroud axial gap region is the primary mechanism for the considerable thermal transport from the mainstream to the turbine blade root/retainer region of the rotor. Author

A92-15673
SELF-INDUCED FLOW IN A STEPPED ROTATING TUBE
S. GILHAM (W.S. Atkins Engineering Sciences, Ltd., Epsom, England), P. C. IVEY (Cranfield Institute of Technology, England), and J. M. OWEN (Bath, University, England) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 9 p. Research supported by Rolls-Royce, PLC. refs
(ASME PAPER 91-GT-276)

Self-induced flow occurs when a tube, open at one end and sealed at the other, is rotated about its central axis: fluid flows along the axis from the open end toward the sealed end and returns in a layer adjacent to the inner surface of the tube. This mechanism, which can occur under isothermal or nonisothermal conditions, is believed to be responsible for the so-called 'hot-poker effect' that was observed during anti-icing tests on the nose bullet of an aeroengine. This paper describes a combined theoretical and experimental study of self-induced flow. It is shown that, for the length-to-diameter (L/D) ratios and rotational Reynolds numbers associated with the anti-icing tubes of aeroengines, the laminar flow near the sealed end of the tube is similar to that of the so-called free disk. Swirl in the air outside the open end reduces the self-induced flow, but flow can reach the sealed end of a stepped tube which has either a sudden contraction or a sudden enlargement. Author

A92-15675
FILM COOLING ON A GAS TURBINE ROTOR BLADE
KENICHIRO TAKEISHI, SUNAO AOKI, TOMOHIKO SATO, and KEIZO TSUKAGOSHI (Mitsubishi Heavy Industries, Ltd., Takasago, Japan) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. refs
(ASME PAPER 91-GT-279)

The film cooling effectiveness on a low-speed stationary cascade and the rotating blade has been measured by using a heat-mass transfer analogy. The film cooling effectiveness on the suction surface of the rotating blade fits well with that on the stationary blade, but a low level of effectiveness appears on the pressure surface of the rotating blade. In this paper, typical film cooling data will be presented and film cooling on a rotating blade is discussed. Author

A92-15676
PERFORMANCE CHARACTERISTICS OF BRUSH SEALS FOR LIMITED-LIFE ENGINES
RAYMOND E. CHUPP (Teledyne CAE, Toledo, OH) and CONSTANCE A. DOWLER (USAF, Wright Laboratory, Wright-Patterson AFB, OH) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. Research supported by USAF and Teledyne CAE. refs
(ASME PAPER 91-GT-281)

Brush seals are potential replacements for air-to-air labyrinth seals in gas turbine engines. An investigation has been conducted to determine the performance characteristics of brush seals for application in limited-life gas turbine engines. An elevated temperature, rotating test rig was designed and built to test labyrinth and brush seals in simulated subsonic and supersonic engine conditions. Results from initial tests for subsonic applications demonstrated that brush seals exhibit appreciably lower leakage compared to labyrinth seals, and thus offer significant engine performance improvements. Performance results have been obtained showing the effect of various brush seal parameters including: initial interference, backplate gap and multiple brush seals in series. Author

A92-15677
MODELLING OF UNSTEADY TRANSITIONAL BOUNDARY LAYERS
J. S. ADDISON and H. P. HODSON (Cambridge, University, England) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 9 p. refs
(ASME PAPER 91-GT-282)

In turbomachinery, a considerable proportion of the blade surface area can be covered by transitional boundary layers. This means that accurate prediction of the profile loss and boundary layer behavior in general depends on the accurate modeling of the transitional boundary layers, especially at low Reynolds numbers. This paper presents a model for determining the intermittency resulting from the unsteady transition caused by the passage of wakes over a blade surface. The model is founded on work by Emmons (1951) who showed that the intermittency could be calculated from a knowledge of the behavior of randomly formed turbulent spots. The model is used to calculate the development of the boundary layer on the rotor of a low Reynolds number single-stage turbine. The predictions are compared with experimental results obtained using surface-mounted hot-film anemometers and hot-wire traverses of the rotor mid-span boundary layer at two different rotor-stator gaps. The validity and limitations of the model are discussed. Author

A92-15681* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NDE OF ADVANCED TURBINE ENGINE COMPONENTS AND MATERIALS BY COMPUTED TOMOGRAPHY
R. N. YANCEY (Advanced Research and Applications Corp., Fairborn, OH), GEORGE Y. BAAKLINI, and STANLEY J. KLIMA (NASA, Lewis Research Center, Cleveland, OH) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 4 p. Research supported by DNA and DARPA. refs
(Contract F33615-89-C-5618; F33615-88-C-2823)
(ASME PAPER 91-GT-287)

Computed tomography (CT) is an X-ray technique that provides quantitative 3D density information of materials and components and can accurately detail spatial distributions of cracks, voids, and density variations. CT scans of ceramic materials, composites, and engine components were taken and the resulting images will be discussed. Scans were taken with two CT systems with different spatial resolution capabilities. The scans showed internal damage, density variations, and geometrical arrangement of various features in the materials and components. It was concluded that CT can play an important role in the characterization of advanced turbine engine materials and components. Future applications of this technology will be outlined. Author

A92-15682
THE USE OF NDE AS A PROCESS DEVELOPMENT TOOL FOR CERAMIC ENGINE COMPONENTS
J. P. POLLINGER (Allied-Signal Aerospace Co., Garrett Ceramic Components Div., Torrance, CA) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 7 p. Research supported by DOE. refs
(ASME PAPER 91-GT-290)

The evaluation of various NDE techniques as inprocess characterization tools during the fabrication development of structural ceramic components for advanced gas turbine

applications is presented. Specific techniques and applications that will be discussed are X-ray microfocus real-time fluoroscopy of slip/cast solid interfaces in parts during slipcasting, NMR imaging of organic binder and moisture concentrations in injection molded and slipcast ceramic parts, and ultrasonic transmission and attenuation techniques used to examine parts during slipcasting and subsequent drying. Author

A92-15688
LDV MEASUREMENTS OF A MIXED-FLOW IMPELLER AT DESIGN AND NEAR STALL
JOHN R. FAGAN and SANFORD FLEETER (Purdue University, West Lafayette, IN) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 13 p. Research supported by U.S. Army. refs
(ASME PAPER 91-GT-310)

A series of experiments are performed to investigate and quantify the design and off-design three-dimensional mean flow in a centrifugal compressor impeller. The experiments entail the acquisition and analysis of LDV data in the impeller passages of a low-speed research mixed-flow compressor operating at its design point and at a point near the inception of rotating stall. The LDV data at both operating points show regions near the impeller exit with a significant velocity deficit on the shroud surface characteristic of the traditional jet-wake structure observed in many centrifugal compressors. At design, the maximum velocity deficit occurs at a location 70 percent of the passage width from the pressure to the suction surface. At the incipient stall point, the maximum velocity deficit occurs in the shroud suction surface corner, with the data indicating reverse flow. Author

A92-15697
DEVELOPMENT OF T-100 MULTIPURPOSE SMALL POWER UNIT
JAMES C. NAPIER (Sundstrand Power Systems, San Diego, CA) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. Research supported by U.S. Army. refs
(ASME PAPER 91-GT-327)

The paper describes the T-100 Multipurpose Small Power Unit (MPSPU), a small gas turbine technology demonstrator that is being developed by the U.S. Army for use in airborne, vehicular, and ground auxiliary power applications. Special attention is given to the design of the power module and other components of the MPSPU and to the component performance. Component rig tests were performed for the inlet protection system, the compressor stage, the combustor, and the turbine stage, demonstrating advances in component capabilities for small turbomachinery. I.S.

A92-15698
GARRETT GTP50-1 MULTIPURPOSE SMALL POWER UNIT TECHNOLOGY DEMONSTRATOR PROGRAM
R. E. ANNATI and J. R. SMYTH (Allied-Signal Aerospace Co., Garrett Auxiliary Power Div., Phoenix, AZ) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 8 p. refs
(Contract DAAJ02-86-C-0006)
(ASME PAPER 91-GT-328)

The Garrett Auxiliary Power Division Multipurpose Small Power Unit development program has demonstrated major advances in small gas turbine power unit design and manufacturing technologies with potential applications to light helicopters, mobile tactical shelters, and combat armored vehicles. This paper discusses the power unit design and performance, component development of the inlet particle separator, compressor, combustor, turbine, and rotor dynamics, and the power unit development. Test results of these units are presented. C.D.

A92-15710* United Technologies Research Center, East Hartford, CT.
NEW APPLICATIONS OF LIQUID-CRYSTAL THERMOGRAPHY IN ROTATING TURBOMACHINERY HEAT TRANSFER RESEARCH
M. F. BLAIR, J. H. WAGNER (United Technologies Research Center, East Hartford, CT), and G. D. STEUBER (Pratt and Whitney Group, East Hartford, CT) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 11 p. Research sponsored by United Technologies Corp. refs
(Contract NAS8-37351)
(ASME PAPER 91-GT-354)

Two new liquid-crystal thermography techniques developed for use in rotating heat transfer experiments are described. In one experiment steady-state heat transfer data were obtained on the exterior surface of rotating turbine airfoil models. In the second study a transient technique was employed to obtain interior-surface heat transfer data in a rotating turbine blade coolant passage model. Sample data are presented in the form of photographs of the liquid-crystal temperature patterns and as contour maps and distributions of heat transfer on the rotor and coolant passage surfaces. Author

A92-15716
ADVANCED CERAMIC ENGINE TECHNOLOGY FOR GAS TURBINES
W. D. CARRUTHERS and J. R. SMYTH (Allied-Signal Aerospace Co., Garrett Auxiliary Power Div., Phoenix, AZ) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 11 p. refs
(ASME PAPER 91-GT-368)

The Advanced Turbine Technology Applications Project is addressing critical technologies for the application of ceramics in gas turbine engines. These technologies include design methods, component development, component fabrication, and engine testing. Both analytical and experimental methods are being used to develop design methods for improving resistance to impact and contact damage. Component improvements are directed at a carbon-free combustor, durable regenerator seals, and an impact-resistant turbine stage design. Subcontractors are utilizing engineered experiments to develop consistent processes to produce high-quality ceramic turbine rotors and other components. These efforts are aimed at achieving satisfactory operation during durability tests at temperatures up to 2500 F and 300 hours operation. Author

A92-15722
A SIMPLE MODEL TO SIMULATE SUBSONIC INTAKES AND PROPELLING NOZZLES OF AIRCRAFT GAS TURBINE ENGINES
I. H. ISMAIL and F. S. BHINDER (Hatfield Polytechnic, England) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 6 p. refs
(ASME PAPER 91-GT-392)

The subsonic intake and the propelling nozzle of aircraft gas turbine engines are modeled for purposes of simulation. Each component is considered as a variable-area duct which is divided into a number of elemental sections. Flow properties are calculated in a step-by-step manner in each section, taking into account friction and area changes. The underlying theory of the model and a brief description of the computer program are given. The program has been written in FORTRAN 77, and runs on IBM AT or compatible microcomputers. Author

A92-15823* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
TURBULENT FLOW CALCULATIONS USING UNSTRUCTURED AND ADAPTIVE MESHES
DIMITRI J. MAVRIPLIS (NASA, Langley Research Center; ICASE, Hampton, VA) International Journal for Numerical Methods in Fluids (ISSN 0271-2091), vol. 13, Nov. 20, 1991, p. 1131-1152.

Previously announced in STAR as N91-10010. refs
Copyright

A method of efficiently computing turbulent compressible flow over complex two dimensional configurations is presented. The method makes use of fully unstructured meshes throughout the entire flow field, thus enabling the treatment of arbitrarily complex geometries and the use of adaptive meshing techniques throughout both viscous and inviscid regions of the flow field. Mesh generation is based on a locally mapped Delaunay technique in order to generate unstructured meshes with highly-stretched elements in the viscous regions. The flow equations are discretized using a finite element Navier-Stokes solver, and rapid convergence to steady-state is achieved using an unstructured multigrid algorithm. Turbulence modeling is performed using an inexpensive algebraic model, implemented for use on unstructured and adaptaive meshes. Compressible turbulent flow solutions about multiple-element airfoil geometries are computed and compared with experimental data.
Author

A92-15972* Toledo Univ., OH.
CASCADE FLUTTER ANALYSIS WITH TRANSIENT RESPONSE AERODYNAMICS
M. A. BAKHLE, A. J. MAHAJAN, T. G. KEITH, JR. (Toledo, University, OH), and G. L. STEFKO (NASA, Lewis Research Center, Cleveland, OH) Computers and Structures (ISSN 0045-7949), vol. 41, no. 5, 1991, p. 1073-1085. Previously announced in STAR as N91-19475. refs
Copyright

Two methods for calculating linear frequency domain aerodynamic coefficients from a time marching Full Potential cascade solver are developed and verified. In the first method, the Influence Coefficient, solutions to elemental problems are superposed to obtain the solutions for a cascade in which all blades are vibrating with a constant interblade phase angle. The elemental problem consists of a single blade in the cascade oscillating while the other blades remain stationary. In the second method, the Pulse Response, the response to the transient motion of a blade is used to calculate influence coefficients. This is done by calculating the Fourier Transforms of the blade motion and the response. Both methods are validated by comparison with the Harmonic Oscillation method and give accurate results. The aerodynamic coefficients obtained from these methods are used for frequency domain flutter calculations involving a typical section blade structural model. An eigenvalue problem is solved for each interblade phase angle mode and the eigenvalues are used to determine aeroelastic stability. Flutter calculations are performed for two examples over a range of subsonic Mach numbers.
Author

A92-16026
LOW-FREQUENCY PRESSURE OSCILLATIONS IN A MODEL RAMJET COMBUSTOR
KEN H. YU (California, University, Berkeley), ARNAUD TROUVE (Stanford University, CA), and JOHN W. DAILY (Colorado, University, Boulder) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 232, Nov. 1991, p. 47-72. refs
(Contract N00014-84-K-0372)
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The paper describes a low-frequency pulsating vortex-driven combustion mode in a dump cavity of a model ramjet combustor facility, which features an abrupt contraction at the cavity outlet and in which the flame was found to be unstable over a wide range of operating conditions. Results of measurements of acoustic pressure and velocity made at various locations in the system showed that the inlet duct of the combustor acts as a long-wavelength acoustic resonator. However, measurements of instability frequency suggest that the instability mechanism is not purely acoustic. Results of schlieren imaging revealed that the instability is associated with large-scale flame-front motions which are driven by periodic vortex shedding at the instability frequency.
I.S.

A92-16089
THREE-DIMENSIONAL CALCULATIONS OF REACTIVE FLOWS IN AIRCRAFT COMBUSTION CHAMBERS PERFORMED USING TWO COMBUSTION MODELS [CALCULS TRIDIMENSIONNELS D'ECOULEMENTS REACTIFS DANS LES CHAMBRES DE COMBUSTION AERONAUTIQUES EFFECTUES A L'AIDE DE DEUX MODELES DE COMBUSTION]
FABIENNE PIT, HELENE TICHTINSKY, PASCALE GILBANK, and FRANCIS DUPOIRIEUX (ONERA, Chatillon, France) (NATO, AGARD, Conference, 77th, San Antonio, TX, May 27-31, 1991) ONERA, TP no. 1991-110, 1991, 16 p. In French. Research supported by SNECMA and DRET. refs
(ONERA, TP NO. 1991-110)

Some 3D calculations have been conducted to predict the reactive flow in aircraft combustion chambers. Two types of combustion models are used. The first model is based on the hypothesis of fast chemistry that can take into account some aspects of the chemical kinetics through an ignition delay. The second, the Lagrangian-Eulerian PEUL model can deal directly with the Arrhenius laws by means of the IEM (interaction by exchange with the mean) submodel and therefore does not require the fast reaction hypothesis. It is demonstrated that the models can be used to analyze 3D turbulent reactive flows in aircraft chambers.
R.E.P.

A92-16615
CARS TEMPERATURE/MULTI-SPECIES MEASUREMENT STRATEGIES FOR HIGH SPEED AIRBREATHING AND ROCKET PROPULSION TESTING
TORGER J. ANDERSON and ALAN C. ECKBRETH (United Technologies Research Center, East Hartford, CT) IN: Symposium (International) on Combustion, 23rd, Orleans, France, July 22-27, 1990, Proceedings. Pittsburgh, PA, Combustion Institute, 1991, p. 1885-1891. refs
(Contract F33615-86-C-2695; F33615-87-C-2702)
Copyright

Multicolor CARS strategies are reviewed for measurements in practical simulations of advanced propulsion systems arranged according to fuel/oxidizer type, i.e., H2-air, H2-O2, hydrocarbon-air, and hydrocarbon-O2. The measurement strategy encompasses the spectral placement of the various laser sources employed and the referencing approaches used to extract quantitative parameter values. Sample CARS measurements are presented from a hydrogen-fueled, air-fed supersonic combustor and an air-fed, hydrocarbon-fueled turboramjet combustor. The experiments were performed using a ruggedized, remotedly controlled, mobile CARS instrument configured for a single pulse (about 10 exp -8 sec) multicolor wave mixing at a 20 Hz repetition rate.
O.G.

A92-16811
EFFECT OF INERTIA FORCES ON THE CHARACTERISTICS OF A LONG HYDRODYNAMIC VIBRATION DAMPER IN THE MIXED FLOW REGIME [VLIIANIE SIL INERTSII NA KHARAKTERISTIKI DLINNOGO GIDRODINAMICHESKOGO DEMPFERA VIBRATSII PRI SMESHANNOM REZHIME TECHENIIA]
V. B. BALIAKIN and A. I. BELOUSOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1990, p. 40-43. In Russian. refs
Copyright

The effect of the convective forces of inertia on the dynamic characteristics of a long hydrodynamic damper in the mixed flow regime is estimated. It is shown, in particular, that the presence of inertia forces gives rise to a radial component of the hydrodynamic force which contributes to an increase in the rotor vibration amplitude. The effect of lubricant cavitation is also discussed.
V.L.

A92-16825
A STUDY OF THE NONLINEAR STRESS-STRAIN STATE OF SPRING-TYPE LANDING GEAR [ISSLEDOVANIE NELINEINOGO NAPRIAZHENNO-DEFORMIROVANNOGO SOSTOIANIIA SHASSI RESSORNOGO TIPA]

V. V. KUZNETSOV and IU. V. SOINIKOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1990, p. 91-93. In Russian. refs

The nonlinear stress-strain state of spring-type landing gear is investigated analytically using approximation relationships of the shell theory. As an example, stress-strain calculations are presented for a leaf spring made of a titanium alloy, with the stress-strain characterized in terms of stress intensity. The results are presented in graphic form. V.L.

A92-16989* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SUPERSONIC REACTING INTERNAL FLOWFIELDS
J. P. DRUMMOND (NASA, Langley Research Center, Hampton, VA) IN: Numerical approaches to combustion modeling. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1991, p. 365-420. Previously announced in STAR as N90-26094. refs

The national program to develop a trans-atmospheric vehicle has kindled a renewed interest in the modeling of supersonic reacting flows. A supersonic combustion ramjet, or scramjet, has been proposed to provide the propulsion system for this vehicle. The development of computational techniques for modeling supersonic reacting flowfields, and the application of these techniques to an increasingly difficult set of combustion problems are studied. Since the scramjet problem has been largely responsible for motivating this computational work, a brief history is given of hypersonic vehicles and their propulsion systems. A discussion is also given of some early modeling efforts applied to high speed reacting flows. Current activities to develop accurate and efficient algorithms and improved physical models for modeling supersonic combustion is then discussed. Some new problems where computer codes based on these algorithms and models are being applied are described. Author

A92-17110 National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
RADIOMETRIC PROPERTIES OF THE NS001 THEMATIC MAPPER SIMULATOR AIRCRAFT MULTISPECTRAL SCANNER
BRIAN L. MARKHAM (NASA, Goddard Space Flight Center, Greenbelt, MD) and SURAIYA P. AHMAD (ST Systems Corp., Lanham, MD) Remote Sensing of Environment (ISSN 0034-4257), vol. 34, Nov. 1990, p. 133-149. Research supported by NASA. refs

Laboratory tests of the NS001 TM are described emphasizing absolute calibration to determine the radiometry of the simulator's reflective channels. In-flight calibration of the data is accomplished with the NS001 internal integrating-sphere source because instabilities in the source can limit the absolute calibration. The data from 1987-89 indicate uncertainties of up to 25 percent with an apparent average uncertainty of about 15 percent. Also identified are dark current drift and sensitivity changes along the scan line, random noise, and nonlinearity which contribute errors of 1-2 percent. Uncertainties similar to hysteresis are also noted especially in the 2.08-2.35-micron range which can reduce sensitivity and cause errors. The NS001 TM Simulator demonstrates a polarization sensitivity that can generate errors of up to about 10 percent depending on the wavelength. C.C.S.

A92-17201* Akron Univ., OH.
TRANSMISSION OVERHAUL AND COMPONENT REPLACEMENT PREDICTIONS USING WEIBULL AND RENEWAL THEORY
M. SAVAGE (Akron, University, OH) and D. G. LEWICKI (NASA, Lewis Research Center, Cleveland, OH) Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, Nov.-Dec. 1991, p. 1049-1054. Previously cited in issue 20, p. 3162, Accession no. A89-47173. refs

A92-17238
NEW PRACTICAL METHOD FOR MEASUREMENT ERROR DETERMINATION IN RADAR SYSTEMS UNDER REAL TRAFFIC CONDITIONS
C. FEIJOO, A. ASENSIO, and F. PEREZ (Escuela Tecnica Superior de Ingenieros de Telecomunicacio, Madrid, Spain) IEE Proceedings, Part F: Radar and Signal Processing (ISSN 0956-375X), vol. 138, Dec. 1991, p. 525-530. Research supported by CESELSA. refs

A new practical approach is presented to aid the evaluation of radar systems. Plots from a data extractor are associated in tracks. Each track is processed through an interpolation filter to achieve a reasonable initialization of the maneuver detector. The tracking filter (alpha-beta) is not used to estimate the target state, but to estimate the measurement errors. The advantages of this new implementation are the simplicity, robustness and ease of testing because of the use of appropriately connected well known tracking algorithms. Finally, some results are introduced. Author

N92-12153# Defence Research Establishment, Ottawa (Ontario). Div. of Electrical Engineering.
AN IMPROVED MODEL-CREATION PROGRAM FOR EM INTERACTION ANALYSIS
S. KASHYAP, M. DION, and A. LOUIE Sep. 1990 3 p Presented at the Canadian Conference on Electrical and Computer Engineering, Ottawa, Ontario, 4-6 Sep. 1990
(NRC-31764; CTN-91-60242) Avail: NTIS HC/MF A01

Several codes are available for computation of the interaction of electromagnetic waves with simple and complicated structures. These codes have been extremely useful in finding numerical solutions to many electromagnetic interaction problems. All the codes have one feature in common: they require as an input the geometry of the object under study. The geometry is supplied as a wire-grid, surface-patch, or cell model, depending on the simulation code. The creation of such geometric data is not an easy task, and the difficulty increases with the complexity of the structure. To help in this regard, DIDEC (digitize, display, edit and convert) was developed at Concordia University a few years ago. Recently the Defence Research Establishment Ottawa (DREO) has made several improvements to DIDEC. DIDEC began as a program that created wire models of a geometric structure using a digitizing tablet. Initially, it created numeric electromagnetic code input files for wire grid structures. Since then it has developed into an interactive program, DIDEC/DREO, for designing wire grid, patch, and cell models of complex structures for solving electromagnetic interaction problems. This paper describes various features of the present version of DIDEC/DREO. Examples are provided which use the system to create models of CP-140 aircraft. CISTI

N92-12154# National Research Council of Canada, Ottawa (Ontario). Div. of Electrical Engineering.
CONSTRAINT PROPAGATION THROUGH ELECTROMAGNETIC INTERACTION TOPOLOGIES
JOE LOVETRI and DARIN P. W. GRAHAM (Toronto Univ., Ontario) Aug. 1990 6 p Presented at the Symposium on Antenna Technology and Applied Electromagnetics, Winnipeg, Manitoba, 15-17 Aug. 1990
(NRC-31761; CTN-91-60243) Avail: NTIS HC/MF A02

The effects of electromagnetic interactions in electrical systems are of concern because of the increasing susceptibility of system components. Heuristic methods are used by engineers to solve electromagnetic interaction problems. An approximate symbolic knowledge representation of a single emitter/path/susceptor problem has been described. In this paper the approximate single emitter/path/susceptor attributes are distributed throughout the electromagnetic topology of a complex system. A constraint based approach for the modelling of the electromagnetic interactions in the system is then described. The approach taken here subdivides the modelling task into: (1) the definition of the related physical topology; (2) constraining topological nodes with specific electromagnetic attributes; and (3) the propagation of the

electromagnetic constraints to determine the probability of failure. The scheme has been implemented in Quintus Prolog on a Sun Sparcstation. The electromagnet topology is represented in Prolog using an object-oriented knowledge representation methodology. A small database containing some attributes of electromagnetic components found on the Canadian NSA helicopter was developed. A coarse topological decomposition of the helicopter was made and the attributes for the various components were entered. This tool was very useful in providing understanding of all the complex interaction paths existing in complex systems. CISTI

N92-12173*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AN ANALYTICAL AND EXPERIMENTAL STUDY TO INVESTIGATE FLUTTER SUPPRESSION VIA PIEZOELECTRIC ACTUATION M.S. Thesis - George Washington Univ., 1991
JENNIFER HEEG 1991 123 p
(NASA-TM-893240; NAS 1.15:893240) Avail: NTIS HC/MF A06 CSCL 09/3

The objective was to analytically and experimentally study the capabilities of adaptive material plate actuators for suppressing flutter. The validity of analytical modeling techniques for piezoelectric materials was also investigated. Piezoelectrics are materials which are characterized by their ability to produce voltage when subjected to a mechanical strain. The converse piezoelectric effect can be utilized to actuate a structure by applying a voltage. For this investigation, a two degree of freedom wind tunnel model was designed, analyzed, and tested. The model consisted of a rigid airfoil and a flexible mount system which permitted a translational and a rotational degree of freedom. It was designed such that flutter was encounted within the testing envelope of the wind tunnel. Actuators, made of piezoelectric material were affixed to leaf springs of the mount system. Each degree of freedom was controlled by a separate leaf spring. Command signals, applied to the piezoelectric actuators, exerted control over the damping and stiffness properties. A mathematical aeroservoelastic model was constructed using finite element methods, laminated plate theory, and aeroelastic analysis tools. Plant characteristics were determined from this model and verified by open loop experimental tests. A flutter suppression control law was designed and implemented on a digital control computer. Closed loop flutter testing was conducted. The experimental results represent the first time that adaptive materials have been used to actively suppress flutter. It demonstrates that small, carefully placed actuating plates can be used effectively to control aeroelastic response. Author

N92-12199 Toledo Univ., OH.
AN EXPERIMENTAL ANALYSIS OF LATERAL JET INJECTION INTO CONFINED SWIRLING CROSSFLOWS Ph.D. Thesis
BRADLEY W. FINTEL 1991 330 p
Avail: Univ. Microfilms Order No. DA9122419

Recently, attention has been devoted to better understanding the complex flows inherent to gas turbine combustors so that fuel efficiency and flame stability may be enhanced. As a contributing factor to the success of these two endeavors, the laterally oriented diffusion jets must be characterized accurately. The current experiment measures lateral jets as injected into a variety of axisymmetric and nonaxisymmetric flowfields using Laser Doppler Anemometry (LDA) and characterizes the general flowfield behavior through the laser sheet method of flow visualization. The investigation also introduces an alternate means of effectively simulating the resulting jet trajectory in a confined circular crossflow. Through a dimensional analysis of the measured data, it was concluded that the jet penetration distances, z/D(sub j), for the nonswirling crossflow cases were found to be best represented in terms of a jet to crossflow momentum ratio, J, and an axial distance, x/D(sub j), according to: z/D(sub j) = 1.373(J)(exp 0.3882)(x/D(sub j))(exp 0.3878). A three dimensional force balance approach was also investigated. The jet trajectory was deduced from the path of a solid sphere. The sphere diameter was found to be a function of the trajectory and the jet to crossflow velocity ratio. The agreement reached between data presented herein and results of previous 2D analyses utilizing conventional hot wire anemometry and pilot probe techniques lends credibility to the LDA measurement technique. Furthermore, it has been demonstrated how a two color, two component LDA data acquisition system offers a desirable alternative for obtaining velocity measurements within a confined rotating flow. In addition, the drag force analogy coupled with the numerical method analyses were found to provide a low cost means of estimating three dimensional jet trajectories for a wide range of crossflow conditions. Dissert. Abstr.

N92-12201 Oxford Univ. (England).
EFFECTS OF WAKE AND SHOCK PASSING ON THE HEAT TRANSFER TO A FILM COOLED TRANSONIC TURBINE BLADE Ph.D. Thesis
M. J. RIGBY 1990 225 p
Avail: Univ. Microfilms Order No. BRD-92714

An attempt is made to further the understanding of film cooling process in an engine environment. The environment in a gas turbine is unsteady. A source of unsteadiness, the cutting of nozzle guide vane (NGV) wakes and shock waves by the rotor, was modeled experimentally. The influence of the unsteady wakes and shock waves on the heat transfer to a film cooled rotor blade was studied for five film cooling configurations using a rotating bar apparatus in front of a 2-D cascade. Heat transfer measurements were made using thin film gauges placed at the mid-span of the test blade. Schlieren photography was used to study the behavior of the coolant film and the movement of the unsteady shock waves and wakes. The effect of simulated NGV wake passing observed on the uncooled airfoil is to promote an intermittent transition of the suction surface. The effect of the wake on the turbulent pressure surface is small. With injection on the suction surface, the film acts as a boundary layer trip which offsets the rise in heat transfer due to the wake. The simulated NGV trailing edge shock wave had a dramatic effect on the suction surface heat transfer.
Dissert. Abstr.

N92-12203 Oxford Univ. (England).
HEAT TRANSFER AND INSTRUMENTATION STUDIES ON ROTATING TURBINE BLADES IN A TRANSIENT FACILITY Ph.D. Thesis
WILLIAM D. E. ALLAN 1990 244 p
Avail: Univ. Microfilms Order No. BRD-92608

The current demands of modern aviation have encouraged engine manufacturers to develop larger, more powerful, yet quieter and more fuel efficient gas turbine engines. This has promoted particular interest in the heat loads borne by turbines, for efficiency can be improved if turbine entry temperature is increased. Presently, ceilings for this parameter are set by the thermal properties of the blade materials and their internal cooling capabilities. It has been established that flow unsteadiness and secondary flows in the turbine passages greatly influence the heat transfer rate on turbine blades and endwall surfaces. The three-dimensionality of the rotating turbine flowfield, however, complicates the interaction of these unsteady effects and their combined role in heat transfer on turbine blades. To fulfill the need to study this complex fluid environment, a model turbine stage has been installed in the working section of the Isentropic Light Piston Tunnel at Oxford. This transient facility enables the rotor to be operated at engine representative conditions. Novel high density instrumentation has been development for use on the turbine blade. Both the production and calibration of the thin film gauges will be explained and the theory supporting heat transfer measurement using this instrumentation is presented in this thesis. Perhaps the most important feature of this thesis lies in the extensive mean and unsteady heat transfer rates measured on the blade profile. These were determined on a total of 5 streamlines and represent a significant contribution to the total experimental data available on 3-dimensional profiles at engine representative conditions.
Dissert. Abstr.

N92-12206 Oxford Univ. (England).
BLADE SURFACE PRESSURE MEASUREMENTS ON THE ROTOR OF A MODEL TURBINE STAGE IN A TRANSIENT FLOW FACILITY Ph.D. Thesis
ANTHONY JOHN DIETZ 1990 251 p
Avail: Univ. Microfilms Order No. BRD-92632

Detailed measurements of the flow through the high pressure stage of a gas turbine engine are required to further the understanding of this complex flow field. A study of the turbine blade surface pressures is reported. Measurements were made of the time averaged and unsteady pressures in a model turbine stage. A blade instrumentation technique was used to make the pressure measurement. Detailed performance testing and calibration of the instrumentation are presented. The surface pressure measurements were made about the midheight streamline of the rotor blade. The time averaged measurements were presented in the form of a blade isentropic Mach number distribution. The results were compared with previous studies of 2-D linear cascades with the same blade profile. Analysis of the unsteady pressure fluctuations included phase locked averages and cross correlations of the data. The effects of wake passing and shock wave passing on the blade surface pressures were detected. The results were compared with previous theoretical analysis and experimental studies of these effects.

Dissert. Abstr.

N92-12216# *Institut de Mecanique des Fluides de Lille* (France).
STUDY OF DETACHED TURBULENT FLOW IN AN AIR INTAKE BY MEANS OF HIGH SPEED TOMOGRAPHY AND LASER VELOCIMETRY [ETUDE DE L'ECOULEMENT TURBULENT DECOLLE DANS UNE PRISE D'AIR EN INCIDENCE PAR TOMOGRAPHIE ULTRA-RAPIDE ET PAR VELOCIMETRIE LASER]
M. STANISLAS, T. LADEN, and J. C. MONNIER 20 Dec. 1990 33 p In FRENCH
(Contract DRET-86-003)
(REPT-90/55; ETN-91-90108) Avail: NTIS HC/MF A03

The internal flow in the air intake of high speed aircraft is studied. Air flow at high speed tends to become detached from the sides of the intake leading to important perturbations in furnishing enough air to the engine and in maintaining constant compressor performance. The output coefficients of the intake are studied in order to better understand the internal flow. Laser velocimetry is used to better understand the internal flow. The dimensions of the intake inlet on the model are measured in order to be able to carry out mathematical modeling of the flow. ESA

N92-12231*# Alabama Univ., Huntsville. Materials Processing Lab.
MODIFICATIONS TO THE RAPID MELT/RAPID QUENCH AND TRANSPARENT POLYMER VIDEO FURNACES FOR THE KC-135 Final Report
GUY A. SMITH, SUE E. KOSTEN, and GARY L. WORKMAN 9 Feb. 1990 33 p
(Contract NAS8-36955)
(NASA-CR-184215; NAS 1.26:184215) Avail: NTIS HC/MF A03
CSCL 14/2

Given here is a summary of tasks performed on two furnace systems, the Transparent Polymer (TPF) and the Rapid Melt/Rapid Quench (RMRQ) furnaces, to be used aboard NASA's KC-135. It was determined that major changes were needed for both furnaces to operate according to the scientific investigators' experiment parameters. Discussed here are what the problems were, what was required to solve the problems, and possible future enhancements. It was determined that the enhancements would be required for the furnaces to perform at their optimal levels. Services provided include hardware and software modifications, Safety DataPackage documentation, ground based testing, transportation to and from Ellington Air Field, operation of hardware during KC-135 flights, and post-flight data processing. Author

N92-12270 Council for National Academic Awards (England).
VARIABLE IMPEDANCE JOURNAL BEARINGS FOR ROTOR-BEARING SYSTEMS Ph.D. Thesis
TIRDAD BOROOMAND 1990 232 p
Avail: Univ. Microfilms Order No. BRDX92789

The oil film in hydrodynamic journal bearings, coupled with the flexibility of the bearing foundation, introduces a significant amount of flexibility into the overall support system of rotating machines, with the consequence of reducing the machine's critical speeds to below those calculated on the basis of pinned supports. Prediction of machine critical speeds and vibration levels is often difficult due to imprecise values for oil film and foundation dynamic stiffness. The aim of this thesis was to develop a new hydrodynamic journal bearing whose dynamic stiffness could be tuned, without upsetting the bearing steady load carrying capacity, in order to shift critical speeds away from the machine normal running speed, and reduce vibration at the critical speeds to a minimum. A theoretical analysis of the bearing design was carried out, based on a finite difference model of the bearing oil film. This analysis enabled the steady state load carrying capacity of the bearing to be calculated for any particular running conditions. The oil film stiffness and damping characteristics were than calculated using the finite displacement technique; these were then used to calculate the unbalance response of a flexible rotor running in such bearings. Experimental measurements of the unbalance response of a model rotor running in the new bearing design were also recorded, and compared with similar measurements obtained when conventional bearings were used. Both theoretical and experimental results show that the proposed new bearing design has a similar steady load carrying capacity to that of conventional hydrodynamic bearings, but that the unbalance response and force transmissibility of machines running in the new bearing design are substantially superior to those obtained with conventional bearings.

Dissert. Abstr.

N92-12286*# National Aeronautics and Space Administration, Washington, DC.
NASA RELIABILITY PREFERRED PRACTICES FOR DESIGN AND TEST
Sep. 1991 98 p
(NASA-TM-4322; NAS 1.15:4322) Avail: NTIS HC/MF A05
CSCL 14/4

Given here is a manual that was produced to communicate within the aerospace community design practices that have contributed to NASA mission success. The information represents the best technical advice that NASA has to offer on reliability design and test practices. Topics covered include reliability practices, including design criteria, test procedures, and analytical techniques that have been applied to previous space flight programs; and reliability guidelines, including techniques currently applied to space flight projects, where sufficient information exists to certify that the technique will contribute to mission success.

Author

N92-12312# Aeronautical Research Inst. of Sweden, Stockholm. Structures Dept.
OPTIMAL DESIGN OF NONLINEAR SHELL STRUCTURES
ULF TORBJOERN RINGERTZ May 1991 35 p Sponsored by Swedish Defence Material Administration, and Swedish Board for Technical Development
(FFA-TN-1991-18; ETN-91-90286) Avail: NTIS HC/MF A03

A numerical method for optimal design of nonlinear shell structures is described. The nonlinearity is only geometrical and the external load is assumed to be conservative. The nonlinear shell is analyzed using standard shell finite elements with the displacements and the rotation of the shell normals as independent analysis variables. Shell thicknesses and cross sectional dimensions of beam stiffeners are used as design variables. The proposed method for optimal design of nonlinear shell structures avoids trying to solve the equilibrium equations directly, given the design variables. This is accomplished by treating both the displacements and rotations describing the deformation, and the design variables. The equilibrium conditions are imposed as

nonlinear equality constraints. Further constraints are imposed on structural stability. The nonlinear optimization problem is solved using a Newton barrier method. The usefulness of the proposed method is demonstrated on shallow stiffened shell structures exhibiting significant nonlinear response, and for which the optimal design corresponds to a structure where the stability constraint is critical. ESA

N92-12313# Aeronautical Research Inst. of Sweden, Stockholm. Structures Dept.
A REVIEW OF AERONAUTICAL FATIGUE INVESTIGATIONS IN SWEDEN DURING THE PERIOD MAY 1989 TO APRIL 1991
ANDERS F. BLOM, ed. 13 May 1991 73 p Presented at 22nd International Committee on Aeronautical Fatigue Conference, Tokyo, Japan, 20-21 May 1991 Sponsored by Swedish Defence Material Administration
(FFA-TN-1991-24; ETN-91-90288) Avail: NTIS HC/MF A04

Work carried out in Sweden in the area of aeronautical fatigue is reviewed. Measurements of aircraft loading actions, basic studies of fatigue development in metals and composites, stress analysis and fracture mechanics, studies of crack propagation and residual strength, testing of joints and full scale structures, and fatigue life predictions are included. ESA

N92-13351# Institute for Defense Analyses, Alexandria, VA.
MODELING RADAR CLUTTER Final Report, Jul. 1990 - May 1991
DAVID A. SPARROW May 1991 37 p
(Contract MDA903-89-C-0003)
(AD-A240965; IDA-P-2464; IDA/HQ-90-35838; AD-E501424)
Avail: NTIS HC/MF A03 CSCL 17/9

Radar detection of aircraft on a particular scan depends in large measure on the clutter return from the target's range cell. The distribution of clutter reflectivities is often so wide that variations of many dB in signature or threshold of detection correspond to changes of only a few percent in PD (probability of detection). Thus, where clutter variability is large, it must be included to avoid errors. However, large clutter variability when included will tend to overwhelm the uncertainties from other sources such as human performance. This may allow simplified treatment of these other sources. We find that the broad distribution of radar returns from environmental features leads to clutter limited detection probabilities that approach unity slowly as range decreases, rather than abruptly as in the noise limited case. GRA

N92-13406# Naval Postgraduate School, Monterey, CA.
FLOW MODIFICATION OVER A BACKWARD FACING STEP M.S. Thesis
MARSHALL L. NARVESON Sep. 1990 100 p
(AD-A241351) Avail: NTIS HC/MF A05 CSCL 01/1

The Naval Postgraduate School (NPS) has undertaken a series of studies on ship air wake tailoring, through the use of deflectors, with the goal of reducing the level of turbulence and the size of the separated zones on the helicopter deck. This reduction will result in a larger engage/disengage envelope, which in turn, will increase the percentage of time that the H-46 and other helicopters can safely operate. This study is the second in the series of NPS to attempt to achieve this goal and considers only the feasibility of tailoring a two-dimensional flow over a backward facing step. Nonporous flat and curved deflectors and porous flat deflectors were mounted in various positions near the edge of the step and the flow patterns recorded using both still and video photography. The deflectors were mounted at varying separations from the step and varying angles to the vertical. It was found that the porous deflectors produced the lowest velocities in the region behind the step, and the nonporous produced the greatest changes in the flow pattern. The results were also compared to the results of the first study that used the PHOENICS computational fluid dynamics program. With one exception, the results differed only by the underprediction of the length of the horizontal flow pattern. GRA

N92-13409# University of Southern California, Los Angeles. Dept. of Aerospace Engineering.
A NEW TECHNIQUE FOR TEMPERATURE AND SPECIE CONCENTRATION MEASUREMENTS IN UNSEEDED SUPERSONIC AND HYPERSONIC GAS FLOWS Final Report, 2 Feb. 1988 - 1 Feb. 1991
DANIEL A. ERWIN, JOSEPH A. KUNC, and E. P. MUNTZ 9 Aug. 1991 16 p
(Contract AF-AFOSR-0119-88; AF PROJ. 2307)
(AD-A241536; AFOSR-91-0808TR) Avail: NTIS HC/MF A03 CSCL 20/4

The goal was to develop an experimental diagnostic technique suitable for gas flows of densities intermediate between atmospheric and rarefied. A laser assisted electron beam fluorescense technique which we call electron photon fluorescense was developed. Theoretical work was done to predict the time dependence of the excitation/deexcitation processes. As described in the original proposal, our goal in this work was the attainment of an experimental diagnostic technique suitable for gas flows of densities intermediate between atmospheric and rarefied. Measurements in such intermediate density flows, typical of hypersonic flight at altitudes above about 50 km, present difficulties in that traditional wind-tunnel techniques (shadow and schlieren, as well as laser based scattering techniques) provide insufficient signal. Moreover, the resonant scattering techniques may require an absorptive species as a tracer to be seeded into the flow, a requirement inconsistent with the realities of existing large facilities. On the other hand, the densities are not enough for continuous electron-beam fluorescence (EBF) to be used due to beam spreading and collisional quenching. GRA

N92-13410# David Taylor Research Center, Bethesda, MD. Propulsion and Auxiliary Systems Dept.
UNSTEADY FLOWS IN ROTOR-STATOR CASCADES Research and Development Report
YU-TAI LEE, THOMAS W. BEIN, JIN Z. FENG, and CHARLES L. MERKLE Mar. 1991 43 p
(AD-A241593; DTRC/PAS-91/7) Avail: NTIS HC/MF A03 CSCL 20/4

A time-accurate potential-flow calculation method has been developed for unsteady incompressible flows through two-dimensional multi-blade-row linear cascades. The method represents the boundary surfaces by distributing piecewise linear-vortex and constant-source singularities on discrete panels. A local coordinate is assigned to each independently moving object. Blade-shed vorticity is traced at each time step. The unsteady Kutta condition applied is nonlinear and requires zero blade trailing-edge loading at each time. Its influence on the solutions depends on the blade trailing-edge shapes. Steady biplane and cascade solutions are presented and compared to exact solutions and experimental data. Unsteady solutions are validated with the Wagner function for an airfoil moving impulsively from rest and the Theodorsen function for an oscillating airfoil. The shed vortex motion and its interaction with blades are calculated and compared to an analytic solution. For multi-blade-row cascade, the potential effect between blade rows is predicted using steady and quasi unsteady calculations. The accuracy of the predictions is demonstrated using experimental results for a one-stage turbine stator-rotor. GRA

N92-13434# General Electric Co., Fairfield, CT.
ROLLING ELEMENT BEARING MEMBER Patent
ERIC N. BAMBERGER, inventor, JOHN C. CLARK, JR., inventor, and ALEXANDER H. NAHM, inventor 3 Jul. 1990 31 p
(PATENT-1-271-213; INT-PATENT-CLASS-F16C-3330; CTN-91-60234) Copyright Avail: Micromedia Ltd., Technical Information Centre, 165 Hotel de Ville, Place du Portage, Phase 2, Hull, Quebec J8X 3X2, Canada HC $4.00 CAN, MF $2.75 CAN

M-50 alloy is a Cr-Mo-V high speed tool steel used extensively in bearings for military and commercial aircraft gas turbine engines. This invention relates to a rolling element bearing comprised of a M-50NiL alloy for use in advanced gas turbine engines. Bearing members with improved life are required for the higher speed,

higher temperature environment of advanced gas turbine engines. The bearing in this invention is comprised of a low carbon ductile core having a hardness less than 50 Rockwell C and a carburized hardened layer of hardness in the range 58 - 66 Rockwell C contiguous with the core. The carburized layer includes no greater than 6 percent retained austenite. This bearing has an improved resistance to crack initiation and propagation at a bearing DN (the bearing bore in millimeters times the shaft speed) of about 2.4 million as a result of compressive residual stress in the carburized layer of about 10-60 ksi. CISTI

N92-13453# National Research Council of Canada, Ottawa (Ontario). Structures and Materials Lab.
VERIFICATION OF NISA 2 AND ENDURE FRACTURE MECHANICS CAPABILITY
J. J. KACPRZYNSKI Feb. 1991 128 p Sponsored in part by Dept. of National Defence and Hawker Siddeley Canada Ltd.
(Contract NAE PROJ. 07335)
(NRC-ST-621; CTN-91-60275) Avail: NTIS HC/MF A07

In any practical damage tolerance analysis of jet engine components, a very large number of cases must be calculated. Each component must be evaluated for several crack lengths, with varying geometry, and for a large number of load cases. A simple, reliable, accurate, and fast finite element code is required to analyse this data. The code should have good pre-processing and good post-processing capabilities, as well as full 3-D fracture mechanics capabilities. As a potential candidate for this kind of analysis, the general finite element code NISA II and its fracture mechanics module ENDURE, is considered. A very extensive study of the performance of NISA II and ENDURE has been performed using several test cases, including both two and three dimensional cases. The present report contains the most representative results of an analysis of one test case, performed with NISA II, Version 89 and ENDURE, Version 90. It is a study of a double edge cracked tension specimen. The specimen was modeled in two forms: (1) as a two dimensional structure modelled with plane strain elements; and (2) as a three dimensional structure modelled with solid elements. Both models should produce identical results; therefore, this provides a simple way to verify the 3-D capability. The results show that the three dimensional fracture mechanics capability of ENDURE is still imperfect. Both the software and the manual of ENDURE require further upgrading before this code can be used as a fully reliable tool for three dimensional fracture mechanics analysis. CISTI

N92-13454# National Research Council of Canada, Ottawa (Ontario). Structures and Materials Lab.
PRELIMINARY FINITE ELEMENT ANALYSIS OF UNLOADED AND LOADED NOTCHED COMPOSITE LAMINATED PLATES
N. C. BELLINGER and C. POON 19 Nov. 1990 34 p
(Contract DND-FE-C0220788NRC21; NAE PROJ. 07336)
(NRC-LTR-ST-1806; CTN-91-60276) Copyright Avail: NTIS HC/MF A03

The lack of stress redistribution in composite laminates is the dominant factor limiting the static strength of composite bolted joints. Bolted joint strength analysis is composed of stress analysis, a failure hypothesis and a failure criterion (strength model). At present, no close-form solutions can accurately predict the stress distribution in the vicinity of the fastener hole. Prior to carrying out a finite element analysis on a composite bolted joint, a preliminary study should be performed on a notched laminated plate which has a stress field similar to the bolted joint in the hole vicinity and the results compared to available closed-form solutions. This paper presents the results from a convergence study on notched laminated plates. A laminated plate with fixed geometry was modelled using the 386PC version of the NISA finite element program to determine the effect that symmetry, and element size and type had on the normal stress distribution. The two dimensional finite element solution was within 3 percent of the values obtained from Whitney and Nuismer's closed-form solutions. The modelling techniques which resulted in accurate stress values were then used to determine the effect of hole diameter and layup on the normal stress distribution of notched laminated plates. These same techniques were also used to model a pin-loaded hole and the results were compared to solutions obtained from a finite element analysis on an identical problem. The results obtained from the NISA finite element program were within 3 percent of the values thereby obtained. Author (CISTI)

N92-13455*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
MEASUREMENTS OF FUSELAGE SKIN STRAINS AND DISPLACEMENTS NEAR A LONGITUDINAL LAP JOINT IN A PRESSURIZED AIRCRAFT
EDWARD P. PHILLIPS and VICKI O. BRITT Oct. 1991 29 p
(NASA-TM-104163; NAS 1.15:104163) Avail: NTIS HC/MF A03 CSCL 20/11

Strains and displacements in a small area near a longitudinal lap joint in the fuselage skin of a B737 aircraft were measured during a pressurization cycle to a differential pressure of 6.2 psi while the aircraft was on the ground. It was found that hoop strains were higher than longitudinal strains at each location; membrane strains in the unreinforced skin were higher than in the joint; membrane strains in the hoop direction, as well as radial displacements, tended to be highest at the mid-bay location between skin reinforcements; significant bending in the hoop direction occurred in the joint and in the skin near the joint, and the bending was unsymmetrically distributed about the stringer at the middle of the joint; and radial displacements were unsymmetrically distributed across the lap joint. The interpretation of the strain gage data for locations on the bonded and riveted lap joint assumed that the joint did not contain disbonded areas. Author

N92-13458*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
TECHNICAL ACTIVITIES OF THE CONFIGURATION AEROELASTICITY BRANCH
STANLEY R. COLE, ed. Oct. 1991 197 p
(NASA-TM-104146; NAS 1.15:104146) Avail: NTIS HC/MF A09 CSCL 20/11

A number of recent technical activities of the Configuration Aeroelasticity Branch of the NASA Langley Research Center are discussed in detail. The information on the research branch is compiled in twelve separate papers. The first of these topics is a summary of the purpose of the branch, including a full description of the branch and its associated projects and program efforts. The next ten papers cover specific projects and are as follows: Experimental transonic flutter characteristics of supersonic cruise configurations; Aeroelastic effects of spoiler surfaces mounted on a low aspect ratio rectangular wing; Planform curvature effects on flutter of 56 degree swept wing determined in Transonic Dynamics Tunnel (TDT); An introduction to rotorcraft testing in TDT; Rotorcraft vibration reduction research at the TDT; A preliminary study to determine the effects of tip geometry on the flutter of aft swept wings; Aeroelastic models program; NACA 0012 pressure model and test plan; Investigation of the use of extension twist coupling in composite rotor blades; and Improved finite element methods for rotorcraft structures. The final paper describes the primary facility operation by the branch, the Langley TDT. Author

N92-13460*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA. Aerostructures Directorate.
DETAILED ANALYSIS AND TEST CORRELATION OF A STIFFENED COMPOSITE WING PANEL
D. DALE DAVIS, JR. Sep. 1991 19 p Presented at the 17th European Rotorcraft Forum, Berlin, Germany, 24-26 Sep. 1991 Prepared in cooperation with Army Aviation Systems Command, Hampton, VA
(NASA-TM-104154; NAS 1.15:104154; AVSCOM-TR-91-B-015)
Avail: NTIS HC/MF A03 CSCL 20/11

Nonlinear finite element analysis techniques are evaluated by applying them to a realistic aircraft structural component. A wing panel from the V-22 tiltrotor aircraft is chosen because it is a typical modern aircraft structural component for which there is

experimental data for comparison of results. From blueprints and drawings supplied by the Bell Helicopter Textron Corporation, a very detailed finite element model containing 2284 9-node Assumed Natural-Coordinate Strain (ANS) elements was generated. A novel solution strategy which accounts for geometric nonlinearity through the use of corotating element reference frames and nonlinear strain displacements relations is used to analyze this detailed model. Results from linear analyses using the same finite element model are presented in order to illustrate the advantages and costs of the nonlinear analysis as compared with the more traditional linear analysis. Strain predictions from both the linear and nonlinear stress analyses are shown to compare well with experimental data up through the Design Ultimate Load (DUL) of the panel. However, due to the extreme nonlinear response of the panel, the linear analysis was not accurate at loads above the DUL. The nonlinear analysis more accurately predicted the strain at high values of applied load, and even predicted complicated nonlinear response characteristics, such as load reversals, at the observed failure load of the test panel. In order to understand the failure mechanism of the panel, buckling and first ply failure analyses were performed. The buckling load was 17 percent above the observed failure load while first ply failure analyses indicated significant material damage at and below the observed failure load. Author

N92-13470# CSA Engineering, Inc., Palo Alto, CA.
PRESERVATION AND UTILIZATION OF FINITE ELEMENT MODELS OF USAF AIRCRAFT STRUCTURES Final Report, Mar. 1989 - Dec. 1990
WARREN C. GIBSON and GORDON N. NEGAARD 23 Aug. 1991 80 p
(Contract F33615-89-C-3205)
(AD-A241657; CSA-91-01-02; WL-TR-91-3055) Avail: NTIS HC/MF A05 CSCL 12/1

The problem addressed by this report is that the Air Force is not getting full value for the resources expended in the development of finite element models of USAF aircraft structures, both directly and by contractors. Models developed by airframe contractors are usually not made available to the Air Force. Models that are available are often inadequately documented or verified, or their existence may be unknown to those who need them. The problem was assessed by a survey of Air Force organizations and was attacked in three ways. First, software called FEM-X was developed for storage and retrieval of finite element model data along with descriptive information about the data. The software could be used by an Air Force Finite Element Model Center. A proposal for establishment of this Center is the second aspect of modification, and distribution of aircraft models. The third subject addressed by the report is a Mil Standard that is proposed for delivery of finite element models by Air Force contractors. GRA

N92-13867*# Texas Univ., Austin. Dept. of Mechanical Engineering.
THE EFFECT OF A TYPE 3 AND TYPE 4 SHOCK/SHOCK INTERACTION ON HEAT TRANSFER IN THE STAGNATION REGION
DENNIS WILSON *In* Old Dominion Univ., NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1991 p 232-235 Sep. 1991
Avail: NTIS HC/MF A12 CSCL 20/4

One of the major engineering challenges in designing the National Aerospace Plane, NASP, is to overcome augmented heating on the intake cowl lip from shock/shock interactions. The shock/shock interaction arises when the bow shock from the craft's nose interferes with the bow shock from the cowl lip. Considering only the region immediately around the cowl lip, the problem geometry may be simplified as that of an oblique shock impinging on a bow shock from a circular cylinder. Edney classified six different interference patterns resulting from an oblique-shock/curved bow-shock interaction. Of these six types, type 3 and 4 are most significant in that augmented surface heat transfer may be ten to thirty times greater than the case without the shock/shock interaction. The objective was to begin to develop a mathematical model which is capable of predicting the effect of a type 3 and 4 shock/shock interaction in the stagnation region of an arbitrary 2-D body. This model must be capable of predicting the maximum surface heat flux and the surface stagnation point pressure once the outer (effectively inviscid) flowfield is given. Therefore, it must capture the unsteady physics of the impinging shear layer. Author

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GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

A92-13809
A IONOSPHERIC-SOUNDING EXPERIMENT FROM AN AIRCRAFT [OPYT ZONDIROVANIIA IONOSFERY S BORTA SAMOLETA]
A. A. STAROVATOV and V. P. MARKOV (Sredneaziatskii *Regional'nyi Nauchno-Issledovatel'skii Gidrometeorologicheskii* Institut, Tashkent, Uzbek SSR) Geomagnetizm i Aeronomiia (ISSN 0016-7940), vol. 31, Sept.-Oct. 1991, p. 949-951. In Russian. refs
Copyright

An ionospheric-sounding experiment from an aircraft was conducted on the Alma-Ata - Osh - Andizhan route in Nov. 1989. The parameters of the ionosphere were found to change during the passage of the aircraft from over steppe to over mountains. Conclusions as to the anisotropy of the D-region are drawn. L.M.

A92-13855
THE NEW AIRPORT AERONAUTIC METEOROLOGICAL CODES [LES NOUVEAUX CODES METEOROLOGIQUES AERONAUTIQUES D'AERODROME]
MICHEL REDDAN (Conseil Superieur de la Meteorologie, Boulogne-Billancourt, France) Navigation (Paris) (ISSN 0028-1530), vol. 39, Oct. 1991, p. 544-549. In French.
Copyright

Amendments to the existing airport meteorological codes recently adopted by ICAO and WMO are presented. The new procedures will lend themselves to electronic data processing in a more satisfactory manner and be better suited for precison approach procedures. These new codes will provide clearer international definitions of time, surface winds, visibility, cloud definition, vertical visibility, and temperature/pressure gradients. R.E.P.

A92-14265
SENSORS AND SYSTEMS TO ENHANCE AVIATION SAFETY AGAINST WEATHER HAZARDS
PRAVAS R. MAHAPATRA (Indian Institute of Science, Bangalore, India) and DUSAN S. ZRNIC (NOAA, National Severe Storms Laboratory, Norman, OK) IEEE, Proceedings (ISSN 0018-9219), vol. 79, Sept. 1991, p. 1234-1267. Research sponsored by FAA. refs
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The authors describe the physics of adverse weather, the basics of Doppler engineering, and a host of advanced sensing systems-some with the ability to autonomously identify and track storm conditions-for all stages of airplane travel. Three major new Doppler radar systems are discussed: the next generation weather radar, the terminal Doppler weather radar, and the airport surveillance radar with a dedicated weather channel. Other relatively simple new instruments for aviation weather support include the low level wind shear alert system, the Doppler wind profilers, the automated weather observation system, and the automated surface observation system. These systems are designed to perform higher level functions such as detection,

characterization, and hazard potential estimation of aviation-significant weather phenomena, as well as their communication and display automatically. I.E.

A92-14925
TWENTY YEARS OF AIRBORNE RESEARCH AT THE UNIVERSITY OF WASHINGTON
PETER V. HOBBS (Washington, University, Seattle) American Meteorological Society, Bulletin (ISSN 0003-0007), vol. 72, Nov. 1991, p. 1707-1716. Research supported by NSF. refs
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A92-15884
SIZE AND CRITICAL SUPERSATURATION FOR CONDENSATION OF JET ENGINE EXHAUST PARTICLES
MARC PITCHFORD (NOAA, Las Vegas, NV), JAMES G. HUDSON, and JOHN HALLETT (Nevada, University, Reno) Journal of Geophysical Research (ISSN 0148-0227), vol. 96, Nov. 20, 1991, p. 20,787-20,793. refs
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In situ measurements of jet engine exhaust from a Sabreliner were made by instruments on board the NCAR Electra during a brief period of coordinated flying. Particle size distribution and critical supersaturation spectra were monitored before, during, and after the encounter with the jet exhaust plume by a condensation nucleus counter, an active scattering aerosol spectrometer probe, and a cloud condensation nuclei (CCN) spectrometer. The relationships between particle size and corresponding critical supersaturation in the background air and within the jet exhaust plume are developed. Results indicate that background particles are much more active as CCN than exhaust particles of the same size, of which less than 1:100 are active at 0.8 percent supersaturation. An estimate of the engine sooting efficiency lies between 3 x 10 exp -5 and exp -6. Author

A92-16080
LIGHTNING ACTIVITY IN MICROBURST PRODUCING STORM CELLS
P. LAROCHE, C. MALHERBE, A. BONDIOU (ONERA, Chatillon, France), M. WEBER, C. ENGHOLM, and V. COEL (MIT, Lexington, MA) (International Conference on Radar Meteorology, 25th, Paris, France, June 24-28, 1991) ONERA, TP no. 1991-98, 1991, 5 p. Research supported by DRET, Direction Generale de l'Aviation Civile, and FAA. refs
(ONERA, TP NO. 1991-98)

The paper describes an experiment performed in Orlando (Florida) during the summer of 1990 to investigate the relationships between lightning and weather conditions that are hazardous to aircraft (such as wind shear, turbulence, and heavy precipitation). The experiment used Doppler radars and a two-station lightning detection system. Preliminary results relating the lightning measurements to the cloud evolution are presented. I.S.

A92-16108
ENVIRONMENTAL IMPACT OF A FUTURE SUPERSONIC TRANSPORT AIRCRAFT [IMPACT SUR L'ENIVRONNEMENT D'UN FUTUR AVION DE TRANSPORT SUPERSONIQUE]
ANDRE GIRARD (ONERA, Direction de la Physique, Chatillon, France) (L'Aeronautique et l'Astronautique, no. 148-149, 1991, p. 37-44) ONERA, TP no. 1991-132, 1991, 9 p. In French. refs
(ONERA, TP NO. 1991-132)

A study is presented on the environmental impact of sonic booms and the effects of NO(x) on the ozone layer. It has been established that an increase of tropospheric ozone concentration is a consequence of an increase in NO(x) injection. At 19 km and higher, injected NO(x) lowers the ozone column. This ozone destruction increases quickly with the altitude of NO(x) injection, at least to 25 km. In addition, attention is given to techniques that might be employed to reduce or negate the effects of the sonic boom in various areas of the environment. R.E.P.

N92-12373# Toronto Univ. (Ontario). Inst. for Aerospace Studies.
THE MODELLING OF TURBULENCE AND DOWNBURSTS FOR FLIGHT SIMULATORS
PAUL AARON ROBINSON Jan. 1991 391 p
(UTIAS-339; ISSN-0082-5255; CTN-91-60269) Avail: NTIS HC/MF A17

This study investigates the degree of complexity required in the simulation of turbulence and thunderstorm downburst wind shear for flight simulation. A turbulence model is presented which contains all the correlations found in homogeneous isotropic turbulence. As part of the development of this turbulence model a method is introduced by which a time series may be modulated to alter its statistical properties while not affecting its spectral properties. Several simplifications and alternate models are considered. This report also presents further developments in the simulation of thunderstorm downbursts. A single ring vortex system, a triple ring vortex system, and joint airport weather studies (JAWS) data are implemented on the University of Toronto, Institute for Aerospace Studies (UTIAS) B-747 Flight Simulator. By means of pilot evaluations on this simulator, it was found that the inclusion of the isotropic turbulence correlations did not seem to affect the pilots' performance or aircraft response. Overall, spectral methods were favored as a means of generating turbulence for flight simulation. Pilot evaluations of the downburst models showed that both single and triple ring vortex systems produced similar pilot reactions to the actual downbursts (JAWS data). It is suggested that the ring vortex models be expanded upon to include more than one downburst cell. Author (CISTI)

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MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

A92-13436
DISTRIBUTED ARTIFICIAL INTELLIGENCE APPROACH TO AIR TRAFFIC CONTROL
N. V. FINDLER (Arizona State University, Tempe) and R. LO (AT&T Bell Laboratories, Holmdel, NJ) IEE Proceedings, Part D - Control Theory and Applications (ISSN 0143-7054), vol. 138, Nov. 1991, p. 515-524. refs
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A distributed planning system applying artificial intelligence to ATC is discussed. A novel coordinator-coworker structure is used as a control mechanism that can dynamically reorganize the planning system in response to the task at hand. The information structure supporting such a control mechanism is made up of hierarchically organized distributed scratch pads. The kernel design of the airborne processors in a location-centered cooperative planning system is described, and the simulation-based planning process and its timing and selection considerations are explained. Three different organizational structures are implemented, and the distributed ATC testbed is introduced and used to compare performance measures of the three organization structures. C.D.

A92-14351
ROTORCRAFT MANEUVERABILITY AND AGILITY SURVIVABILITY SENSITIVITY ANALYSIS (RMASSA)
SCOTT R. SWINSICK and SHARON L. DRUMMOND (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 351-357. refs
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Using a fractional-factorial study matrix, combinations of baseline and improved levels of helicopter maneuverability and

agility (M&A) have been used to investigate different aircraft configurations in air-to-air, air-to-ground, and AirLand Engagement Simulation combat models. The M&A performance parameters most critical to survivability have been identified. Using Taguchi methods a study matrix that studied the critical performance parameters across three levels was developed; the matrix represented derivative helicopter designs which reflected improved M&A qualities. O.C.

A92-14367
A FULL MISSION SIMULATION DATA SYSTEM
JOAN EDWARDS (Sikorsky Aircraft, Stratford, CT) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 565-577.
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A system to automatically collect data from the full mission simulation of a complex rotorcraft system and to generate a statistically significant sample data set that is used to compute measures of performance has been implemented at Sikorsky Aircraft. As part of the Light Helicopter (LH) Demonstration Validation Program, this data system was successfully exercised to provide mission data from nearly forty simulation experiments. Data collected from these full-mission piloted simulations was used, for the first time in the helicopter industry, to assess performance of a rotorcraft system before the aircraft was actually built. This paper describes the types of data that are collected and provides insight into how these data are used to assess the design of as system that is simulated. It presents details on the two aspects of this comprehensive data system: automatic data collection and interactive data reduction. Author

A92-14368* Georgia Inst. of Tech., Atlanta.
A NEW METHOD FOR SIMULATING ATMOSPHERIC TURBULENCE FOR ROTORCRAFT APPLICATIONS
J. V. R. PRASAD, D. P. SCHRAGE (Georgia Institute of Technology, Atlanta), G. H. GAONKAR (Florida Atlantic University, Boca Raton), and J. RIAZ IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1. Alexandria, VA, American Helicopter Society, 1991, p. 579-584. refs
(Contract NCA2-512)
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Simulation of atmospheric turbulence as seen by a rotating blade element involves treatment of cyclostationary processes. Conventional filtering techniques do not lend themselves well to the generation of such turbulence sample functions as are required in rotorcraft flight dynamics simulation codes. A method to generate sample functions containing second-order statistics of mean and covariance is presented. Compared to ensemble averaging involving excessive computer time, the novelty is to exploit cycloergodicity and thereby, replace ensemble averaging by averaging over a single-path sample function of long duration. The method is validated by comparing its covariance results with the analytical and ensemble-averaged results for a widely used one-dimensional turbulence approximation. Author

A92-14387* Virginia Polytechnic Inst. and State Univ., Blacksburg.
A NEURAL NETWORK FOR THE IDENTIFICATION OF MEASURED HELICOPTER NOISE
R. H. CABELL, C. R. FULLER, and W. F. O'BRIEN (Virginia Polytechnic Institute and State University, Blacksburg) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 817-828. Research supported by USAF. refs
(Contract NAS1-18471)
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The results of a preliminary study of the components of a novel acoustic helicopter identification system are described. The identification system uses the relationship between the amplitudes of the first eight harmonics in the main rotor noise spectrum to distinguish between helicopter types. Two classification algorithms are tested; a statistically optimal Bayes classifier, and a neural network adaptive classifier. The performance of these classifiers is tested using measured noise of three helicopters. The statistical classifier can correctly identify the helicopter an average of 67 percent of the time, while the neural network is correct an average of 65 percent of the time. These results indicate the need for additional study of the envelope of harmonic amplitudes as a component of a helicopter identification system. Issues concerning the implementation of the neural network classifier, such as training time and structure of the network, are discussed. Author

A92-14393
CONCURRENT ENGINEERING AT BOEING HELICOPTERS
BRIAN CHIESI, TONY PARASIDA, and ERIC WALLISER (Boeing Defense and Space Group, Helicopters Div., Philadelphia, PA) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 921-930.
Copyright

Concurrent engineering methods, which consider all elements of the product life cycle from conception through fabrication, have been implemented on the MH-47E and V-22 pilot production programs, and are part of the planning for the LH prototype program. By these means, the product, its manufacturing processes, and the requisite life-cycle support processes, are simultaneously defined. These concurrent methods employ the CATIA Computer-Aided Three-dimensional Interactive Application 2D/3D graphics system for electronic mockups and digital preassembly. Digital preassembly automatically checks for fit-and-function errors within the CATIA data base to prevent engineering errors from reaching the factory floor. O.C.

A92-15332
A DEVELOPMENT OF COMPUTER SUPPORT SYSTEM FOR WING DESIGN
Y. MUROTSU, C. S. PARK (Osaka Prefecture, University, Sakai, Japan), and M. ICHIKAWA (Japan Research Institute, Ltd., Osaka, Japan) Chinese Journal of Aeronautics (ISSN 1000-9361), vol. 4, May 1991, p. 141-149. refs
Copyright

Since it takes a long time to design an aircraft, the succession to or the acquirement of knowledges and technologies is a key to provide to aircraft design high quality and productivity. The paper describes a computer support system for wing design using a new tool based on an object-oriented approach. The system is programmed in a module of objects which represent design tasks or design knowledges. The modulated program gives advantages to maintain and extend the system easily. The system provides to users a flexible support with excellent user interface which consists of a mouse, a menu-driven system, and a window system. Author

A92-15513
PRELIMINARY EXPERIENCE WITH AN EXPERT SYSTEM PROVIDING INITIAL CENTRIFUGAL COMPRESSOR SIZING FOR PERFORMANCE PREDICTION AND ANALYSIS
PETER M. SCHOONMAKER (Northern Research and Engineering Corp., Woburn, MA) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 7 p. refs
(ASME PAPER 91-GT-28)

There are many problems in turbomachinery which do not lend themselves to numerical analysis. One such area is the preliminary design of centrifugal compressor stages. It seems likely that expert systems technology and object-oriented programming techniques will be able to make some impact on this class of problems. This paper presents the results of the first phase of a project designed to test this assumption. This paper describes a simple methodology for establishing the initial parameters of centrifugal compressor stages up to a pressure ratio of 5.0. The method combines heuristic rules and empirical relationships, with some very simple optimization routines. It requires very little input from the user other than aerodynamic performance requirements. Phase 1 of this project

uses this methodology to estimate the initial geometry of a centrifugal compressor impeller. Author

A92-15701* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
COMPUTATIONS OF UNSTEADY MULTISTAGE COMPRESSOR FLOWS IN A WORKSTATION ENVIRONMENT
KAREN L. GUNDY-BURLET (NASA, Ames Research Center, Moffett Field, CA) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 36th, Orlando, FL, June 3-6, 1991. 10 p. refs
(ASME PAPER 91-GT-336)

High-end graphics workstations are becoming a necessary tool in the Computational Fluid Dynamics (CFD) environment. In addition to their graphics capabilities, the latest generation of workstations have powerful floating point operation capabilities. As workstations become common, they could provide valuable computing time for applications, such as turbomachinery flow calculations. This paper discusses the issues involved in implementing an unsteady, viscous multistage turbomachinery code (STAGE-2) on workstations. The workstation version of STAGE-2 has then been used to study the effects of axial-gap spacing on the time-averaged and unsteady flow within a 2 1/2-stage compressor. Results include force polar plots, time-averaged pressure contours, standard deviation of pressure contours, time-averaged surface pressures and pressure amplitudes. Author

A92-16072
STUDY OF THE DISCRETE SINGULARLY PERTURBED LINEAR-QUADRATIC CONTROL PROBLEM BY A BILINEAR TRANSFORMATION
ZORAN GAJIC and XUE-MIN SHEN (Rutgers University, Piscataway, NJ) Automatica (ISSN 0005-1098), vol. 27, Nov. 1991, p. 1025-1028. refs
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This paper presents a new approach in the study of the linear quadratic control problem of singularly perturbed discrete systems. By applying a bilinear transformation, the algebraic discrete Riccati equation is converted into a continuous one, which can be solved by using the reduced-order recursive method already documented in the control literature. This method produces the reduced-order near-optimal solution up to an arbitrary order of accuracy and reduces the size of required computations. The method is very suitable for parallel programming. A real world example, an F-8 aircraft, demonstrates the efficiency of the proposed method. Author

A92-16826
A STUDY OF A VERSION OF THE BOUNDARY CONDITIONS OF A TWO-DIMENSIONAL SPLINE IN SURFACE AND LINE MODELING [ISSLEDOVANIE VARIANTA KRAEVYKH USLOVII DVUMERNOGO SPLAINA PRI MODELIROVANII POVERKHNOSTEI I OBVODOV]
A. N. ROTKIN, V. F. SNIGIREV, and V. G. SHATAEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1990, p. 93-96. In Russian. refs
Copyright

The use of splines for the interpolation and approximation of surfaces is examined, and the associated errors are discussed. In particular, results of a numerical experiment concerned with the spline interpolation of surfaces using rectangular finite elements are presented for two versions of spline functionals. Both versions demonstrate practically the same convergence. V.L.

A92-16832
THE DESIGNER-FEM MODEL INTERFACE BASED ON THE DATA BASE MANAGEMENT CONCEPT [INFORMATSIONNAIA SVIAZ' 'KONSTRUKTOR - MKE MODEL", OSNOVANNAIA NA KONTSEPTSII UPRAVLENIIA BAZAMI DANNYKH]
V. A. ZARUBIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1990, p. 109-111. In Russian. refs
Copyright

A conceptual architecture is considered which is intended for the storage and manipulation of data in RIPAK, a finite-element system for the design of aviation structures. The architecture proposed here enables the user to get answers to spontaneous, unplanned questions about the strength, stiffness, dynamic, and aeroelastic characteristics of the structure being designed by directly accessing the data base using the data manipulation language. The high flexibility and efficiency of such a system is demonstrated. Requirements for the practical implementation of the proposed architecture are defined. V.L.

N92-12440*# Edgerton, Germeshausen and Grier, Inc., Idaho Falls, ID.
AN INDEPENDENT REVIEW OF THE MULTI-PATH REDUNDANT AVIONICS SUITE (MPRAS) ARCHITECTURE ASSESSMENT AND CHARACTERIZATION REPORT
M. R. JOHNSON Feb. 1991 23 p
(Contract NASA ORDER L-53177-C; DE-AC07-76ID-01570)
(NASA-CR-188126; NAS 1.26:188126; DE91-018692; EGG-EE-9479) Avail: NTIS HC/MF A03 CSCL 09/2

In recent years the NASA Langley Research Center has funded several contractors to conduct conceptual designs defining architectures for fault tolerant computer systems. Such a system is referred to as a Multi-Path Redundant Avionics Suite (MPRAS), and would form the basis for avionics systems that would be used in future families of space vehicles in a variety of missions. The principal contractors were General Dynamics, Boeing, and Draper Laboratories. These contractors participated in a series of review meetings, and submitted final reports defining their candidate architectures. NASA then commissioned the Research Triangle Institute (RTI) to perform an assessment of these architectures to identify strengths and weaknesses of each. This report is a separate, independent review of the RTI assessment, done primarily to assure that the assessment was comprehensive and objective. The report also includes general recommendations relative to further MPRAS development. DOE

N92-12451# Federal Ministry for Defence, Bonn (Germany, F.R.).
TOOL SUPPORTED SOFTWARE DEVELOPMENT EXPERIENCES FROM THE EFA PROJECT
WERNER M. FRAEDRICH *In* AGARD, Software for Guidance and Control 7 p Sep. 1991
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The European Fighter Aircraft (EFA) Project is a multinational project. Agreement had to be reached between the partner nations (industry and government) with respect to pertinent data processing support. It is shown that general agreements were worked out by arriving at the lowest common denominator since none of the participating nations were prepared to accept standards established by another partner nation; an attempt to solve this problem is presented. The following topics are addressed: (1) some general information on the EFA Project, including important determinations; (2) the status of the software tool selection and procurement in *the EFA Project; and (3) a comparison between required and* actual availability of software tools in the EFA Project. Author

N92-12452# Smiths Industries Aerospace and Defence Systems Ltd., Cheltenham (England).
MILITARY AND CIVIL SOFTWARE STANDARDS AND GUIDELINES FOR GUIDANCE AND CONTROL
K. W. WRIGHT *In* AGARD, Software for Guidance and Control 13 p Sep. 1991
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The two most widely used standards covering the development of software in the military and civil avionics industries are DOD-STD-2167A and the Radio Technical Commission for Aeronautics (RTCA) DO.178A/European Organization for Civil Aviation Electronics (EUROCAE) ED-12A, respectively. This latter document is currently undergoing extensive update by RTCA Special Committee (SC) 167 and EUROCAE Working Group (WG)

12, with a planned document re-issue date of the end of 1991. A comparison of DOD-STD-2167A with the work currently being undertaken by SC.167/WG.12. Author

N92-12461# Electronic System G.m.b.H., Munich (Germany, F.R.).
PROCESS/OBJECT-ORIENTED ADA SOFTWARE DESIGN FOR AN EXPERIMENTAL HELICOPTER
K. GRAMBOW *In* AGARD, Software for Guidance and Control 7 p Sep. 1991
Copyright Avail: NTIS HC/MF A11; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Discussed here is the software design method for real-time applications written in Ada. It proves that even time critical systems can be implemented in pure Ada. The design method is based on the Ada tasking model in conjunction with object oriented (OOD) principles. Special purpose graphs, derived from Yourdon/DeMarco data flow diagrams (DFDs), illustrate the method, while Ada program design language (PDL), as a counterpart to the graphs, serves as a basis for the software implementation. No global executive is used to schedule the concurrent threads of execution. Instead, a rendezvous-based interaction of Ada tasks provides the scheduling. This is automatically generated from an Ada compiler. This software design technique is illustrated by the development of the operational flight software for an experimental helicopter. Author

N92-12469# LITEF, Freiburg (Germany, F.R.).
DEVELOPMENT AND VERIFICATION OF SOFTWARE FOR FLIGHT SAFETY CRITICAL SYSTEMS
H. AFZALI and A. MATTISSEK *In* AGARD, Software for Guidance and Control 4 p Sep. 1991
Copyright Avail: NTIS HC/MF A11; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

In Flight Safety Critical System errors in the Computer Software components can have a catastrophic impact on the safety. For the development of the equipment software, a set of development standards and additional procedures for the implementation of Safety Critical Functions are defined. The standards and procedures were applied for the development of the Inertial Measurement Unit which is a part of the Flight Control System and Seat Sequencer Unit which is part of the Ejection Seat. Some critical technology needs for supporting the development and verification process of such systems and activities which have to be performed during the development phases for identifying, assessing, and eliminating or minimizing hazards in a systematic way are described. Author

N92-12517# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Avionics Panel.
MACHINE INTELLIGENCE FOR AEROSPACE ELECTRONIC SYSTEMS
Sep. 1991 301 p In ENGLISH and FRENCH Symposium held in Lisbon, Portugal, 13-16 May 1991
(AGARD-CP-499; ISBN-92-835-0628-6) Copyright Avail: NTIS HC/MF A14; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The papers presented at the Avionics Panel Symposium are compiled. The results of efforts applying Machine Intelligence (MI) technology to aerospace electronic applications are discussed. The symposium focused on application research and development to determine the types of MI paradigms which are best suited to the wide variety of aerospace electronic applications.

N92-12520# Rome Air Development Center, Griffiss AFB, NY.
HEURISTIC ROUTE OPTIMIZATION: A MODEL FOR FORCE LEVEL ROUTE PLANNING
JANET L. BARBOZA *In* AGARD, Machine Intelligence for Aerospace Electronic Systems 6 p Sep. 1991
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A major shortcoming of tools and methods currently employed for route planning is that they do not incorporate force-level factors, or, if they do, the representation is inadequate. Many important factors necessary for approaching the best possible route are ignored. Heuristic Route Optimization, or HERO, is a model for automated route generation for force-level mission planning. Object Oriented techniques and a dynamic threat representation allow detailed analysis of multiple planning variables in producing effective, survivable mission plans. Author

N92-12528*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
A NASA/RAE COOPERATION IN THE DEVELOPMENT OF A REAL-TIME KNOWLEDGE BASED AUTOPILOT
COLIN DAYSH, MALCOLM CORBIN, GEOFF BUTLER, EUGENE L. DUKE, STEVEN D. BELLE, and RANDAL W. BRUMBAUGH (PRC Systems Services Co., Edwards, CA.) *In* AGARD, Machine Intelligence for Aerospace Electronic Systems 10 p Sep. 1991 Sponsored in part by Ministry of Defence
Copyright Avail: NTIS HC/MF A14; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive
CSCL 01/3

As part of a US/UK cooperative aeronautical research program, a joint activity between NASA-Ames and the Royal Aerospace Establishment on Knowledge Based Systems (KBS) was established. This joint activity is concerned with tools and techniques for the implementation and validation of real-time KBS. The proposed next stage of the research is described, in which some of the problems of implementing and validating a Knowledge Based Autopilot (KBAP) for a generic high performance aircraft will be studied. Author

N92-12542# Wright Lab., Wright-Patterson AFB, OH.
ENGINEERING GRAPHICAL ANALYSIS TOOL (EGAT) DEVELOPMENT PROGRAM
VICTOR R. CLARK and JOSEPH R. DIEMUNSCH *In* AGARD, Machine Intelligence for Aerospace Electronic Systems 10 p Sep. 1991
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The Air Force Avionics Laboratory has sponsored many efforts to develop real-time Artificial Intelligence (AI) systems. One of these systems, the Adaptive Tactical Navigation (ATN) Program, developed a prototype system to intelligently control a future tactical fighter's integrated navigation sensors. ATN was developed using a distributed communicating expert object architecture called the Activation Frame (AF). Using the AF architecture, ATN was able to achieve real-time execution. Real-time execution was primarily achieved due to the AF's distributed control scheme which eliminates many of the bottlenecks associated with centralized schedulers. Unfortunately, with these increased benefits, there is increased complexity associated with correctly setting the distributed control parameters. The Engineering Graphical Analysis Tool (EGAT) was developed to overcome these limitations by providing a user friendly, graphical AF development tool. EGAT provides the capability to dynamically monitor and modify the AF control parameters. The AF architecture, and the development and implementation of the EGAT are described. The EGAT system is used to dynamically monitor and modify the decentralized control parameters of the AF architecture, a communicating expert object paradigm. Author

N92-13746# Carnegie-Mellon Univ., Pittsburgh, PA. Dept. of Electrical and Computer Engineering.
BEHAVIOR-BASED FAULT MONITORING
JOHN P. SHEN 3 Dec. 1990 4 p
(Contract N00014-86-K-0507)
(AD-A241254) Avail: NTIS HC/MF A01 CSCL 12/6

An approach is developed which exploits the deterministic behavior of a processor to perform concurrent fault monitoring. A very low cost and highly effective technique, called Continuous Signature Monitoring (CSM), has been developed. This technique is capable of detecting transients with very low detection latency, and requires very minimal memory overhead and performance penalty. This technique has been applied to both CISC and RISC

type processors. Both analytical and experimental results have been obtained in validating the effectiveness of the approach. CSM has been adopted by two aerospace companies in their design of a 32-bit RISC processor targeted for avionics and space applications. It appears that the signature monitoring technique can be extended to detect computer viruses as well via a form of program encryption. GRA

N92-13835*# University of South Florida, Tampa. Dept. of Civil Engineering and Mechanics.
COMPARISON OF POLYNOMIAL APPROXIMATIONS AND ARTIFICIAL NEURAL NETS FOR RESPONSE SURFACES IN ENGINEERING OPTIMIZATION
WILLIAM C. CARPENTER *In* Old Dominion Univ., NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1991 p 68-80 Sep. 1991
Avail: NTIS HC/MF A12 CSCL 09/2

Engineering optimization problems involve minimizing some function subject to constraints. In areas such as aircraft optimization, the constraint equations may be from numerous disciplines such as transfer of information between these disciplines and the optimization algorithm. They are also suited to problems which may require numerous re-optimizations such as in multi-objective function optimization or to problems where the design space contains numerous local minima, thus requiring repeated optimizations from different initial designs. Their use has been limited, however, by the fact that development of response surfaces randomly selected or preselected points in the design space. Thus, they have been thought to be inefficient compared to algorithms to the optimum solution. A development has taken place in the last several years which may effect the desirability of using response surfaces. It may be possible that artificial neural nets are more efficient in developing response surfaces than polynomial approximations which have been used in the past. This development is the concern of the work. Author

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PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

A92-14384* McDonnell-Douglas Helicopter Co., Mesa, AZ.
DEVELOPMENT OF A SHOCK NOISE PREDICTION CODE FOR HIGH-SPEED HELICOPTERS - THE SUBSONICALLY MOVING SHOCK
H. TADGHIGHI, R. HOLZ (McDonnell Douglas Helicopter Co., Mesa, AZ), F. FARASSAT, and YUNG-JANG LEE (NASA, Langley Research Center, Hampton, VA) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 773-790. refs
Copyright

A previously defined airfoil subsonic shock-noise prediction formula whose result depends on a mapping of the time-dependent shock surface to a time-independent computational domain is presently coded and incorporated in the NASA-Langley rotor-noise prediction code, WOPWOP. The structure and algorithms used in the shock-noise prediction code are presented; special care has been taken to reduce computation time while maintaining accuracy. Numerical examples of shock-noise prediction are presented for hover and forward flight. It is confirmed that shock noise is an important component of the quadrupole source. O.C.

A92-14385* Sikorsky Aircraft, Stratford, CT.
ACOUSTIC PREDICTIONS USING MEASURED PRESSURES FROM A MODEL ROTOR IN THE DNW
JOSEPH A. VISINTAINER (Sikorsky Aircraft, Stratford, CT), CASEY L. BURLEY, MICHAEL A. MARCOLINI (NASA, Langley Research Center, Hampton, VA), and SANDY R. LIU (U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 791-806. refs
Copyright

A contemporary design, 4-bladed United Technologies model rotor with pressure-instrumented blades was tested in the Duits-Nederslandse Windtunnel. Simultaneous acoustic and pressure measurements were made for a wide range of operating conditions. Microphones were optimally positioned at a number of locations in the flow forward of the rotor to measure rotor thickness noise, high-speed impulsive noise (both in the rotor plane), and blade-vortex interaction noise (forward and 25 deg below the rotor plane). The blade surface pressure data are used as aerodynamic input to WOPWOP, which is a state-of-the-art rotor noise prediction program that predicts rotor thickness and loading noise. The predicted results using WOPWOP are compared to the measured noise levels for cases where either thickness noise, blade-vortex interaction noise, or high-speed impulsive noise is the dominant noise mechanism. The comparisons show regions of good agreement, as well as areas where further improvement is necessary. Author

A92-14386
COMPUTATION OF THE BVI NOISE FOR THE BO105 MODEL ROTOR IN FORWARD FLIGHT AND COMPARISON WITH WIND TUNNEL TESTS
M. SCHAFFAR, J. HAERTIG, and P. GNEMMI (Saint-Louis, Institut Franco-Allemand de Recherches, France) IN: AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 2. Alexandria, VA, American Helicopter Society, 1991, p. 807-816. refs
Copyright

The vortex lattice method jointly used with a local conformal mapping (to transform the thin blade into a thick one) is briefly described. This method is applied to a four-bladed rotor (BO105-Model Rotor) for two flight conditions. The noise emission in a plane below the rotor is calculated with an acoustic code which is based on the Ffowcs-Williams and Hawkings (FW-H) equation and the results are compared with tests in the German-Dutch wind tunnel. The aerodynamic results (thrust curve, wake evolution, vortex shedding) are analyzed. The contour map of the peak-to-peak noise shows the dependence of the results on the cutoff distance, on the method of regularization, on the flight parameters and on the thick profile type. Nevertheless, in all cases, the computed noise pressure level is near the measured one and the noise directivity shows the predominance of the advanced blade/vortex interaction. Some problems remain to be solved, especially the influence of a smaller time step. Author

A92-16138
THEORETICAL STUDY AND PREDICTION OF BVI NOISE INCLUDING CLOSE INTERACTIONS
PIERRE SPIEGEL and GILLES RAHIER (ONERA, Chatillon, France) ONERA, TP no. 1991-174, 1991, 12 p. Research supported by DRET. refs
(ONERA, TP NO. 1991-174)

The following study deals with the highly impulsive blade-vortex interaction (BVI) noise which is generated by helicopter main rotors in descent flight. Two computer codes have been especially designed to predict it at reduced computing costs, starting from given vortices. The aerodynamic code, called MAIR, predicts the unsteady airloads, even for head-on collisions, by using a singularity method and modeling the vortices as cloud vortices with viscous cores. The acoustic code, called PARIS, computes the resulting radiated loading noise and is based on the Ffowcs Williams and Hawkings equation. These two codes are ready to perform noise prediction in the flight cases but the vortex prediction required for input data still needs to be improved. While waiting for better wake data, the two codes have been used for a theoretical parametric study of arbitrary single blade-vortex interactions. This study gives a physical insight of the phenomenon and its predicted tendencies could help designing quieter blades. Author

A92-16824
EFFECT OF THE WAKE FLOW ON THE SOUNDPROOFING OF AIRCRAFT STRUCTURES [O VLIIANII SPUTNOGO POTOKA NA ZVUKOIZOLIATSIIU SAMOLETNYKH KONSTRUKTSII]
A. V. GENERALOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1990, p. 89-91. In Russian. refs
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The effect of the wake flow on the soundproofing of aircraft structures is calculated analytically for a single-layer structure for zero and nonzero Mach numbers. The results obtained indicate that the wake flow contributes to the sound insulation of aircraft structures. The greatest benefit from the standpoint of sound insulation is achieved when the powerplant is located in the tail section of the aircraft. V.L.

N92-12598*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
HELICOPTER MAIN-ROTOR SPEED EFFECTS: A COMPARISON OF PREDICTED RANGES OF DETECTION FROM THE AURAL DETECTION PROGRAM ICHIN AND THE ELECTRONIC DETECTION PROGRAM ARCAS
ARNOLD W. MUELLER and CHARLES D. SMITH (Lockheed Engineering and Sciences Co., Hampton, VA.) Sep. 1991 16 p
(NASA-TM-104134; NAS 1.15:104134) Avail: NTIS HC/MF A03 CSCL 20/1

NASA LaRC personnel have conducted a strudy of the predicted acoustic detection ranges associated with reduced helicopter main rotor speeds. This was accomplished by providing identical input information to both the aural detection program ICHIN 6, (I Can Hear It Now, version 6) and the electronic acoustic detection program ARCAS (Assessment of Rotorcraft Detection by Acoustics Sensing). In this study, it was concluded that reducing the main rotor speed of the helicopter by 27 percent reduced both the predicted aural and electronic detection ranges by approximately 50 percent. Additionally, ARCAS was observed to function better with narrowband spectral input than with one-third octave band spectral inputs and the predicted electronic range of acoustic detection is greater than the predicted aural detection range.
Author

N92-13757*# Lockheed Aeronautical Systems Co., Burbank, CA.
DEVELOPMENT AND TESTING OF CABIN SIDEWALL ACOUSTIC RESONATORS FOR THE REDUCTION OF CABIN TONE LEVELS IN PROPFAN-POWERED AIRCRAFT Final Report, Oct. 1986 - Dec. 1990
H. L. KUNTZ, R. J. GATINEAU, R. A. PRYDZ, and F. J. BALENA Washington NASA Oct. 1991 162 p
(Contract NAS1-18036)
(NASA-CR-4388; NAS 1.26:4388; LG90ER0119) Avail: NTIS HC/MF A08 CSCL 20/1

The use of Helmholtz resonators to increase the sidewall transmission loss (TL) in aircraft cabin sidewalls is evaluated. Development, construction, and test of an aircraft cabin acoustic enclosure, built in support of the Propfan Test Assessment (PTA) program, is described. Laboratory and flight test results are discussed. Resonators (448) were located between the enclosure trim panels and the fuselage shell. In addition, 152 resonators were placed between the enclosure and aircraft floors. The 600 resonators were each tuned to a propfan fundamental blade passage frequency (235 Hz). After flight testing on the PTA aircraft, noise reduction (NR) tests were performed with the enclosure in the Kelly Johnson Research and Development Center Acoustics Laboratory. Broadband and tonal excitations were used in the laboratory. Tonal excitation simulated the propfan flight test excitation. The resonators increase the NR of the cabin walls around the resonance frequency of the resonator array. Increases in NR of up to 11 dB were measured. The effects of flanking, sidewall absorption, cabin absorption, resonator loading of trim panels, and panel vibrations are presented. Resonator and sidewall panel design and test are discussed. Author

N92-13758*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DEVELOPMENT OF AN ANNOYANCE MODEL BASED UPON ELEMENTARY AUDITORY SENSATIONS FOR STEADY-STATE AIRCRAFT INTERIOR NOISE CONTAINING TONAL COMPONENTS
JAMES R. ANGERER, DAVID A. MCCURDY, and RICHARD A. ERICKSON (Boeing Commercial Airplane Co., Seattle, WA.) Sep. 1991 85 p
(NASA-TM-104147; NAS 1.15:104147) Avail: NTIS HC/MF A05 CSCL 20/1

The purpose of this investigation was to develop a noise annoyance model, superior to those already in use, for evaluating passenger response to sounds containing tonal components which may be heard within current and future commercial aircraft. The sound spectra investigated ranged from those being experienced by passengers on board turbofan powered aircraft now in service to those cabin noise spectra passengers may experience within advanced propeller-driven aircraft of the future. A total of 240 sounds were tested in this experiment. Sixty-six of these 240 sounds were steady state, while the other 174 varied temporally due to tonal beating. Here, the entire experiment is described, but the analysis is limited to those responses elicited by the 66 steady-state sounds. Author

N92-13759*# Sverdrup Technology, Inc., Brook Park, OH.
PREDICTION OF NOISE FIELD OF A PROPFAN AT ANGLE OF ATTACK Final Report
EDMANE ENVIA Oct. 1991 22 p Presented at the Sixth International Symposium on Unsteady Aerodynamics, Aerocoustics, and Aeroelasticity of Turbomachines and Propellers, Notre Dame, IN, 15-19 Sep. 1991; sponsored by the International Union for Theoretical and Applied Mechanics
(Contract NAS3-25266)
(NASA-CR-189047; E-6645; NAS 1.26:189047) Avail: NTIS HC/MF A03 CSCL 20/1

A method for predicting the noise field of a propfan operating at an angle of attack to the oncoming flow is presented. The method takes advantage of the high-blade-count of the advanced propeller designs to provide an accurate and efficient formula for predicting their noise field. The formula, which is written in terms of the Airy function and its derivative, provides a very attractive alternative to the use of numerical integration. A preliminary comparison shows rather favorable agreement between the predictions from the present method and the experimental data.
Author

N92-13822# California Inst. of Tech., Pasadena.
EXPERIMENTAL SIMULATION AND DIAGNOSTICS OF HIGH-ENTHALPY REAL-GAS FLOWS Annual Progress Report
1991 4 p
(Contract N00014-90-J-1305)
(AD-A241286) Avail: NTIS HC/MF A01 CSCL 20/11

The very high flow speeds (up to 8km/s) of transport to and from space through the earth's atmosphere are necessarily associated with very high temperatures (up to 10,000 K) in ground testing and research facilities. Therefore, such facilities have to operate only for very short test times. Various techniques have been devised for generating a test flow of sufficient speed and density to simulate the thermal and kinetic processes of high-temperature gasdynamics correctly. Of these, the shock tunnel and the expansion tube principle are the most successful, and in both cases the high enthalpy regime requires the driver gas to be heated transiently to high temperatures (up to 4,000 K). This can most conveniently be achieved by a piston compression. Many new and only partially understood effects occur in the flows associated with the NASP. Dissociative non-equilibrium effects in the external flow, mixing, and combustion processes in supersonic combustion ramjet engines and boundary layers in real-gas flows pose new problems that can presently not be solved by computational fluid dynamics (CFD) techniques. Key experimental data are needed to test and supply parameters for CFD methods.
GRA

N92-13857*# Polytechnic Univ., Brooklyn, NY. Dept. of Mathematics.
CRITICAL PROBLEMS OF COMPUTATIONAL AEROACOUSTICS
JOEL C. W. ROGERS *In* Old Dominion Univ., NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1991 p 190-197 Sep. 1991
Avail: NTIS HC/MF A12 CSCL 20/1

The aeroacoustics of rigid boundaries is discussed. Lighthill gave a formulation of this problem in which he showed that the sources of the acoustic field were quadrupole in nature. We have preferred a different formulation of the problem, in which the quadrupoles are sources for a nonlinear wave equation, as opposed to the linear one used by Lighthill. This is given here in a figure which also gives further details of a solution procedure for the Euler equations appropriate for the aeroelastic problem and motivated by the analysis of Crow. In accordance with our formulation, we contend that an algorithm for accurate solutions of an inhomogeneous nonlinear wave equation is of prime importance. Author

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SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

A92-16134
LEGAL CAPACITY OF EUROCONTROL TO ENSURE SMOOTH AVIATION IN EUROPE
A. A. MAJID (City of London Polytechnic, England) Air Law (ISSN 0165-2079), vol. 16, Dec. 1991, p. 267-279. refs
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The problem of organizing European airspace is examined in terms of the causes of the problem, remedial steps that have been taken, the use and extent of Eurocontrol, and a proposed functional solution. Lack of coordination in the fragmented European atc system is identified as the major obstacle to the efficient use of airspace. Early remedial action included a directive for close collaboration and the development of a Europe-wide switching center based in London for 4D atc services. Eurocontrol (the proposed European Organization for the Safety of Air Navigation) is introduced, and the role of the organization is to provide analysis of atc needs, development of air-navigation plans, and promotion of common policies and research. The functional solution for Eurocontrol expands the operational functions of the organization and permits wider powers in planning and coordination to stem waste and promote safer airspace. C.C.S.

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GENERAL

A92-16062
DESIGN IS THE NAME OF THE GAME - COMPARISON OF THE F5D SKYLANCER TO THE F4D SKYRAY
ROBERT O. RAHN (Society of Experimental Test Pilots, Lancaster, CA) IN: 1990 report to the aerospace profession; Society of Experimental Test Pilots, Symposium, 34th, Beverly Hills, CA, Sept. 27-29, 1990, Proceedings. Lancaster, CA, Society of Experimental Test Pilots, 1990, p. 171-194.
Copyright

A comprehensive evaluation is conducted of the development of the Skylancer, which first flew in 1956, from the Skyray, through fuselage lengthening and wing slenderizing to reduce supersonic drag and increase internal fuel capacity by a factor of 2. Attention is given to the resulting changes in roll rate, maximum Mach number, supersonic longitudinal control, pitch damping, proverse yaw, and spins. The results of USN evaluations of the aircraft performance characteristics obtained are discussed. O.C.

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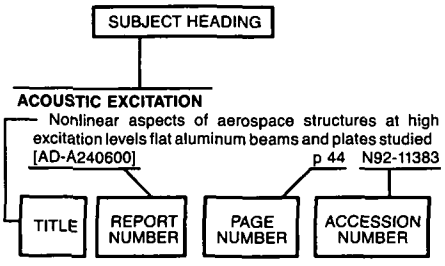

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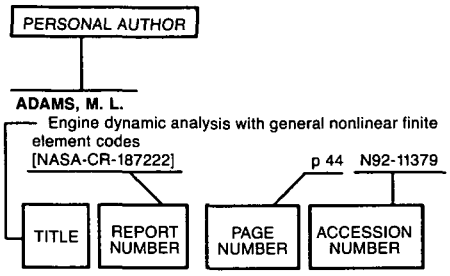

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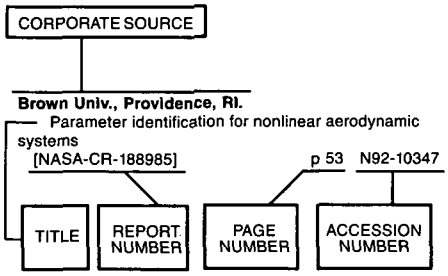

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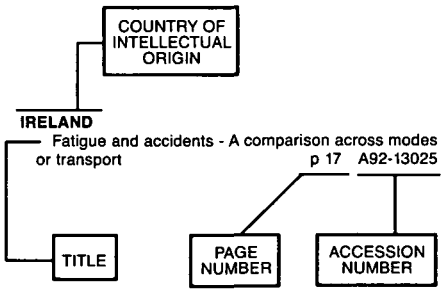

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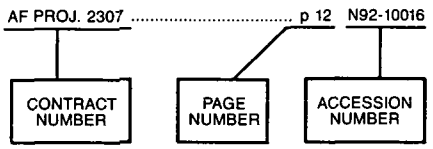

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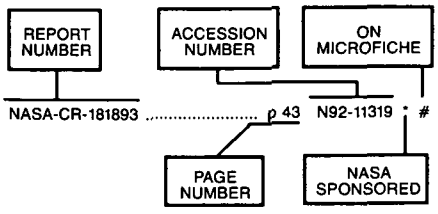

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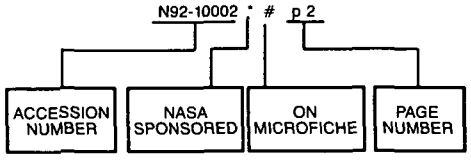

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